DOCUMENT RESUME

ED 204 633 CE 029 608

TITLE Military Curricula for Vocational & Technical Education. Painting I, II. 3-6.

INSTITUTION Army Engineer School, Fort Belvoir, Va.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.

SPONS AGENCY Bureau of Occupational and Adult Education (DHEW/OE), Washington, D.C.

PUB DATE [78]

NOTE 241p.; Photographs and some diagrams will not reproduce well.

EDRS PRICE MF01/PC10 Plus Postage.

DESCRIPTORS Autoinstructional Aids; Behavioral Objectives; *Building Trades; *Equipment Utilization; *Individualized Instruction; Learning Activities; *Painting (Industrial Arts); Postsecondary Education; Safety; Secondary Education; Skilled Occupations; Tests; Textbooks; *Trade and Industrial Education; Workbooks

IDENTIFIERS Military Curriculum Project

ABSTRACT

These two student workbooks with texts for a secondary-postsecondary level course in painting comprise one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The two-part self-study course is designed to provide the student with basic information on safety, equipment, and procedures in painting. Painting I contains four lessons dealing with materials and equipment: Safety, Protective Coating Materials, Protective Coating Equipment, and Ladders, Scaffold, and Metal Corrosion. Painting II contains four lessons dealing with application procedures: Painting Wood Surfaces, Painting Masonry Surfaces, Painting Metal Surfaces, and Inspection of Surfaces. Each lesson is organized in this format: text assignment, objective, review exercises, and answers keyed to the coded text for self-evaluation. The text follows the lessons in each part. Thirty-question final examinations are provided for each unit, but no answers are available. (YLB)

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ED 204673

Military Curricula for Vocational & Technical Education

CE 029 608

PAINTING I, II
3-6

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
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217/782-0759

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The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials

WRITE OR CALL

Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

Developed by:

United States Army

Development and Review Dates

Unknown

Occupational Area:

Building and Construction

Cost: $3.00

Print Pages: 139

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Suggested Background:

None

Target Audiences:

Grades 10-adult

Organization of Materials:

Text; student workbook with objectives, exercises, solutions, and discussion of exercises; and unit tests

Type of Instruction:

Individualized, self-paced

Type of Materials:		No. of Pages:	Average Completion Time:
Painting I —	*Materials and Equipment*	100	Flexible
	Student Workbook and Examination	33	
Painting II —	*Application*	72	Flexible
	Student Workbook and Examination	34	

Supplementary Materials Required:

None

THE CENTER FOR VOCATIONAL EDUCATION

Course Description:

This two part course is designed to provide the student with basic information on safety, equipment, and procedures in painting. Some of the competencies included are:

- Recognize hazards associated with paint materials and equipment and take safety measures that prevent accidents
- Select, use and store paint and protective coating materials properly
- Operate, maintain and store the equipment used in applying protective coating
- Use ladders and scaffolds safely
- Detect and prevent metal corrosion
- Prepare wood, masonry, and metal surfaces for protective coating
- Inspect surfaces, evaluate paints and workmanship, and calculate surface areas

Painting I contains four lessons each containing an objective, text, review exercises, and answers, dealing with materials and equipment.

Lesson 1 – *Safety* covers general safety, accident hazards, fire hazards, health hazards, emergencies, and health services.

Lesson 2 – *Protective Coating Materials* covers the purpose, function, composition, and types of protective coatings; mixing and preparing surface preparation materials; selecting exterior and interior protective coatings; and handling, storing and disposing of protective coatings.

Lesson 3 – *Protective Coating Equipment* covers surface preparation equipment, application equipment, traffic markers, and sign making equipment.

Lesson 4 – *Ladders, Scaffold, and Metal Corrosion* covers types of ladders, scaffolds, and hoisting equipment and types of corrosion, causes of corrosion, corrosion control and metal identification.

Painting II contains four lessons dealing with application procedures.

Lesson 1 – *Painting Wood Surfaces* deals with general characteristics of wood, preparation and application of protective coating to interior and exterior surfaces, and camouflage painting.

Lesson 2 – *Painting Masonry Surfaces* deals with characteristics of concrete and masonry surfaces, preparation and application of protective coatings to interior and exterior masonry surfaces, and the application of traffic markings.

Lesson 3 – *Painting Metal Surfaces* contains information about visible identification of corrosion, preparing and applying protective coatings to interior and exterior metal surfaces, repairing metal surfaces, metal conditioning and pretreatment, and application of stencils and markings.

Lesson 4 – *Inspection of Surfaces* deals with inspection of old and new protective coatings as well as supervisory tasks.

This course is designed for student self-study with objectives, text, and self-graded tests. The text is coded and all questions are keyed to the text for self evaluation. Thirty-question final examinations are provided for each unit, but no answers are available.

THE CENTER FOR VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

PAINTING I, II

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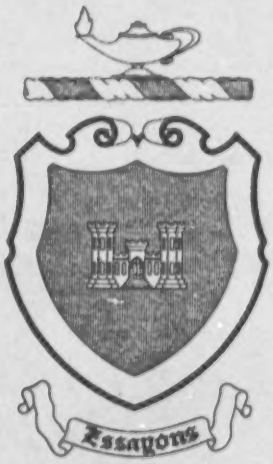
ENGINEER 4

SUBCOURSE 562



PAINTING I

(MATERIALS AND EQUIPMENT)

CORRESPONDENCE COURSE PROGRAM

U. S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA

12

NRI 106

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INTRODUCTION

This subcourse is the first of two subcourses on the subject of painting. It begins with a review of those aspects of safety practice that are of continuous importance to the painter. This is followed by instruction on the selection and mixing of paints, the operation and maintenance of paint equipment and the proper storage of paint supplies. In addition, a chapter is devoted to the identification of metals and to the methods employed to detect and prevent corrosion.

This subcourse consists of four lessons and an examination as follows:

Lesson 1. Safety.

2. Protective Coating Materials.

3. Protective Coating Equipment.

4. Ladders, Scaffolding, and Metal Corrosion.

Examination.

Ten credit hours are allowed for this subcourse.

You will not be limited as to the number of hours that you may spend on the subcourse, any lesson, or the examination. For statistical purposes, you are required to enter in the proper space on each answer sheet the number of hours spent in studying the text and solving the exercises.

Text Furnished: Memorandum 562, Painting I.

To facilitate removal, answer sheets are bound in reverse order at the end of this publication. Make sure that the number on the answer sheet is the same as the lesson on which you are working.

Each exercise has four choices with only ONE best answer. Select the choice that you beiieve is best. Then turn to the answer sheet and mark an X through the letter representing that choice.

The examination will be sent to you when you have successfully completed all the lessons.

LESSON 1

SAFETY

CREDIT HOURS ---------- 2

TEXT ASSIGNMENT ---------- Memorandum 562, Chapter 1.

LESSON OBJECTIVE ---------- To teach you the hazards associated with paint materials and equipment and to explain the safety measures that prevent accidents.

EXERCISES

Requirement: Solve the following multiple-choice exercises.

1. Which of the following types of paint is not flammable?

a. oil-base

b. red-lead primer

c. rubber base

d. water-thinned

2. Painters who are sensitive to toxic or skin-irritating materials must take special precautions. Of the following materials, which is the only one they should work with?

a. water-thinned paints

b. varnish

c. oil paints

d. texture paint

3. Which of the following would you use to protect yourself against paint fumes and solvent vapors?

a. dispersoid respirator

b. supplied-air respirator

c. safety helmet

d. chemical-cartridge respirator

4. Your safety goggles should

a. have breakable lenses to permit emergency escape of trapped fumes

b. have only straight-ahead vision to exclude peripheral distractions

c. fit loosely for quick, emergency removal

d. have unbreakable glass or plastic lenses

5. You wear a safety helmet for protection against which of the following?

a. abrasive blasting

b. solvent vapors

c. falling objects

d. acid cleaners

6. Painters should not wear clothing with tears, rips or loose pockets because they are

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a. distracting

b. causes of accidents

c. unsightly

d. not useful

7. Which of the following do you consider most important in working in a hazardous area?

a. drop cloth

b. disciplinary action

c. buddy system

d. duplicate equipment

8. The most common and serious accidents that occur during painting operation are caused by

a. inhalation of fumes

b. improper storage of equipment

c. fire

d. loss of footing

9. How tall may a stepladder be, in feet, for use while painting?

a. 16 c. 12

b. 14 d. 10

10. What minimum percentage of overlap do you require for each section in an extension ladder?

a. 25 c. 15

b. 20 d. 10

11. You are placing a ladder against the wall of a structure. How far out, at least, would you place the feet of the ladder?

a. two feet

b. ¼ working length of ladder

c. ½ working length of ladder

d. 1 yard

12. At what height above the ground would you insist that a scaffold have full length guard railings?

a. at any height

b. 50 feet

c. twice length of scaffold

d. 25 feet

13 Most paint products are flammable. What are the chief causes of fire and explosions?

a. liquids and vapors

b. high-flash solvents

c. rubber-base paints

d. damar varnishes and lacquers

14. What is the diameter in inches of the smallest size casters that you would use on a rolling tower?

a. 3 c. 5

b. 4 d. 6

15. It is standard practice to use wire rope of at least ¾ inch diameter for platform slings. What is the least diameter in inches of manila rope that you would select for boatswain chairs and lifelines?

a. 1 c. ¾

b. ½ d. ⅝

16. Every gallon of solvent in spray paint will create how many gallons of potentially dangerous gas or vapor?

a. fewer than 100

b. more than 100

c. 100

d. 50

17. What would you place under dispensing pumps and spigots to absorb any spillage or overflow?

a. oiled rags

b. pails of sand

c. box of sawdust

d. pail of water

18. What precaution do you take with paint rags and waste?

a. burn them

b. soak in oil and leave in place

c. wet down with water and store in closed metal container

d. wash and dry thoroughly

19. Which is the most common solvent that is used in nonflammable paint removers?

a. turpentine

b. xylol

c. methylene chloride

d. MEK

20. Which of the following solvents is least irritating to the skin?

a. mineral spirits

b. turpentine

c. methyl ethyl ketone

d. xylol

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LESSON 2

PROTECTIVE COATING MATERIALS

CREDIT HOURS 2

TEXT ASSIGNMENT ..... Memorandum 562, Chapter 2.

LESSON OBJECTIVE ..... To teach you selection and use of paints, and to explain the methods of safely handling and storing paint materials.

EXERCISES

Requirement: Solve the following multiple-choice exercises.

1. Which of these coatings should not be used for exterior finishing?

a. damar varnish
b. spar varnish
c. oil-base paint
d. rubber-base paint

2. Why do you add driers to protective coatings?

a. hasten film hardening
b. protect the pigment
c. keep pigment in the solution
d. increase viscosity

3. You are making aluminum paint from aluminum powder. You mix the powder according to formula, with

a. glue
b. water
c. varnish
d. shellac

4. What would you do with empty paint containers after their contents of old and dried out paint have been dumped into a sanitary fill?

a. put them into a Dempsey Dumpster
b. dump them into sanitary fill
c. use them for storing filler
d. burn them

5. Oil-based paints are

a. very expensive
b. not durable
c. hard to color
d. easy to apply

6. You want to waterproof a concrete block wall. The best base paint for such waterproofing is

a. silicone
b. oil
c. lacquer
d. varnish

7. What is zinc oxide?

a. varnish
b. vehicle
c. pigment
d. shellac

8. You have been given the job to paint a steel bridge. Which of the following do you apply?

a. red lead primer and aluminum

b. zinc chromate and deck enamel

c. aluminum paint and water emulsion

d. red iron oxide and asphalt varnish

9. Which of the following would you select to provide a smooth, even finish on open-grain wood?

a. size

b. phenolic-resin primer-sealer

c. texture paint

d. wood filler

10. The label on a paint can states the color and type of paint and

a. viscosity

b. date of manufacture

c. consistency

d. blending characteristics

11. Tints are lighter than

a. shades
c. hues

b. tones
d. chromas

12. You are painting a previously painted wood surface that is in good condition. The primer is

a. added to undercoat

b. added to sealer

c. thinned

d. omitted

13. You are painting a wooden wall that has an absorbent surface. Which of the following would you apply before starting to paint?

a. shellac and alcohol

b. stain

c. aluminum pigment

d. zinc oxide

14. For best results the temperature of paint materials should be between

a. 40° F and 55° F

b. 50° F and 60° F

c. 60° F and 70° F

d. 65° F and 85° F

15. You want to mix 5 gallons of paint that contain a highly volatile thinner. What method do you use?

a. boxing
c. propeller

b. paddling
d. shaker

16. You must paint walk stripes in a building. These stripes must glow in the dark. Which of these do you use?

a. aluminum paint

b. highway yellow with glass beads

c. luminous paint

d. titanium dioxide

17. Zinc oxide is a desirable coating for the inside of a water tank because it

a. admits ultraviolet light

b. is nonpoisonous

c. is white

d. is fast drying

18. Which of the following would you use to apply joint cement to a sheetrock joint?

a. float
c. putty knife

b. chisel
d. screwdriver

19. In selecting a can of paint from the storeroom, you pick the one that

a. has lowest temperature

b. is on top of the stack

c. bears the oldest date

d. requires no stirring

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20. Of the choices below, which you use as a primer on a steel bridge?

a. zinc chromate
b. epoxy
c. phenolic resin
d. hot alkyd varnish

LESSON 3

PROTECTIVE COATING EQUIPMENT

CREDIT HOURS ---------- 2

TEXT ASSIGNMENT ---------- Memorandum 562, Chapter 3.

LESSON OBJECTIVE ---------- To teach you the operation, maintenance, and storage of the equipment used in applying protective coating.

EXERCISES

Requirement: Solve the following multiple-choice exercises.

1. You must paint several large pieces of equipment that are encrusted with grease and dirt. You first clean them with

a. a vacuum cleaner

b. a buffer

c. an abrasive blaster

d. a steam cleaner

2. When you are stenciling signs, you have 2 or 3 sets of brass stencils with you because

a. paint builds up on brass quickly

b. many signs have duplicate letters

c. avoids cleaning a stencil after each use

d. stencil letters easily bend out of shape

3. Which of these would you use to sharpen a chisel?

a. grinding wheel

b. file

c. rasp

d. emery

4. You are using a fountain stencil brush. You control the flow of ink by

a. releasing the snaplock

b. adjusting the thumbscrew

c. using strong pressure on brush

d. using the shutoff valve

5. You are selecting a new abrasive wheel to put on a portable power grinder. The safe operating speed of the new wheel is checked

a. on the wheel blotter

b. in the tool crib

c. in the applicable TO

d. on the spark plug

6. Which of these would you use to remove paint from a metal storm door?

a. flint paper

b. garnet paper

c. aluminum oxide

d. rottenstone

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7. The airless spray gun develops a high pressure that presents the danger of sparking between the gun and the object to be sprayed. What precaution do you take?

a. spray only during low humidity

b. ground both gun and object

c. wear shock-resistant rubber gloves

d. use explosion-proof motor

8. You put a push-broom handle into the handle of a roller coater. Why?

a. to provide more leverage

b. to get coater into corners easily

c. to apply more paint in one movement

d. to reach high places without using scaffolding

9. You must paint a large gymnasium building. Which of these do you use for this volume painting?

a. stencil sprayer

b. self-contained spray gun

c. pressure-feed paint gun

d. low-pressure spray unit

10. Which of these would you use to clean rust from a protruding bolt head?

a. grinder

b. steam cleaner

c. disc sander

d. descaler

11. Which of these would you use to sand a drywall joint?

a. edger

b. buffer

c. vibrator sander

d. disc sander

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12. You are using a compressor with a gasoline engine. You would change the oil filter

a. when oil is renewed

b. after every job

c. when dipstick shows 1 quart low

d. whenever gas tank is filled

13. To remove excess paint from your brush when you are painting, the brush should be

a. wiped with a cloth

b. tapped against inside of container

c. wiped on rim of paint can

d. rubbed on hidden part of job

14. Why are glass spheres added to traffic-marking paint?

a. decrease amount of paint work

b. increaze durability of the paint

c. improve the base coat

d. reflect the light

15. What should a good quality brush have?

a. flagged bristles

b. metal handle

c. two rows of bristles

d. horsehair bristles

16. On which of the following would you use an abrasive belt?

a. floor edger

b. drum sander

c. disc sander

d. vibrator sander

17. Which of these would you use to spray a small area with quick-drying lacquer?

a. low-pressure spray unit

b. high-pressure spray unit

c. suction spray gun

d. vibrator pump

18. In order to smooth the finish between coats of paint on fine woodwork, you use

a. grit abrasive

b. pumice stone

c. file

d. a scraper

19. You are running a power-operated traffic marking machine. Which of the following could partly control the width of the paint spray?

a. type of gun nozzle

b. thumbscrew on paint tank

c. speed of drive pulley

d. distance of gun nozzle from pavement

20. What type spray gun would you connect directly to a small compressor?

a. internal mixing

b. bleeder

c. nonbleeder

d. suction feed

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LESSON 4

LADDERS, SCAFFOLDING, AND METAL CORROSION

CREDIT HOURS 2

TEXT ASSIGNMENT ..... Memorandum 562, Chapters 4 and 5.

LESSON OBJECTIVE ..... To teach you how to use ladders and scaffolds and what methods to use for detecting or preventing metal corrosion.

EXERCISES

Requirement: Solve the following multiple-choice exercises.

1. Extension ladders are extended by means of

a. springs

b. block and tackle

c. hoisting machine

d. couplings with safety devices

2. You use a hoisting machine to raise a swing stage scaffold. What action do you take before leaving that machine?

a. raise scaffold higher than needed, then lock

b. tie yourself securely to scaffold

c. remove control handle and lock brake

d. push yourself slowly away from building

3. When a ladder is not in use, you hang it on brackets by its side rails in order to prevent

a. penetration of moisture

b. use by unauthorized persons

c. warping

d. splitting

4. When the erected swing stage scaffold is not in use, it must be

a. lashed to the building

b. lowered to the ground

c. kept upright

d. disassembled

5. You are placing a 24-foot ladder against a wall that you will paint. How many feet from the wall do you place the bottom of the ladder?

a. 6 c. 10

b. 8 d. 12

6. You want to form a loop in the end of a rope that is easily untied but will not slip. What knot do you use?

a. clove hitch c. half hitch

b. rolling hitch d. bowline

7. Which knot would you use with the boatswain chair to allow the workman to lower himself slowly?

a. clove hitch

b. half hitch

c. double bowline

d. rolling hitch

8. You are erecting a swing stage scaffold on a building. How do you keep it from swinging outward after it has been hoisted?

a. place weights on outside edge

b. workman keeps hands on building during hoisting

c. lash swing stage to the building

d. equip with stirrup rollers

9. You are on a 15-foot ladder and need help to complete the job. You tell your helper to

a. start painting from lower side

b. get another ladder

c. get onto your ladder with you

d. erect a lean-to scaffold

10. You are erecting a rolling tower which will be 4 feet square in base dimension. How high, in feet, do you make the tower?

a. 12 c. 20

b. 16 d. 24

11. Metals that cannot be identified by visual examination or mechanical testing might be identified through use of

a. a magnet

b. color numbers

c. a grinder

d. an acid-spot test

12. Where does corrosion of metal begin?

a. on exposed surface

b. during milling

c. before coagulation

d. in the core

13. What method of corrosion protection uses a sacrificial anode to protect the structure?

a. impressed current

b. concentration cell

c. galvanic anode

d. differential

14. Two years ago a storage tank was constructed. Cold rivets were used to join the steel sheets. Your present inspection shows corrosion in the joined parts. What type of corrosion is this?

a. stress c. intergranular

b. galvanic d. exfoliation

15. The impressed current method of cathodic protection prevents corrosion to a metal structure by

a. a source of alternating current

b. a stronger electrolyte

c. preventing corrosiveness of the soil

d. balancing the electrical potential

16. Which four conditions must be present before electro-chemical corrosion occurs?

a. electrolyte, conductor, cathode, metal anode

b. cathode, anode, electrolyte, organic film

c. metal anode, conductor, organic film, cathode

d. organic film, anode, cathode, electrolyte

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17. Which of the following could produce a condition leading to corrosion?

a. reducing voltage of rectifier

b. viscosity of the paint

c. passivation

d. misidentifying metal

18. If you cannot positively identify a metal by visual identification, it should be

a. tested for unusual stress

b. given magnet and spark tests

c. treated as steel

d. given ring test

19. Corrosion presents a greater problem when it occurs in the vicinity of

a. a school building housing woodworking equipment

b. a manufacturing plant with 100 automotive vehicles

c. electrified coal mines

d. an office building lighted by fluorescent lighting

20. In a pipeline laid in cinders, corrosion occurs where the current

a. accumulates on pipe interior

b. is equalized

c. leaves the pipe

d. enters the pipe

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 562 ---------- Painting I.

LESSON 1 ---------- Safety.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 562.

1. *d* (par 1-2)
2. *a* (par 1-9)
3. *d* (par 1-11(*b*))
4. *d* (par 1-12)
5. *a* (par 1-13)
6. *b* (par 1-13)
7. *c* (par 1-14)
8. *d* (par 2-1)
9. *d* (par 2-3*a*(8))
10. *c* (par 2-3*a*(7))
11. *b* (par 2-3*a*(9))
12. *a* (par 2-3*b*(5))
13. *a* (par 3-1)
14. *d* (par 2-3*c*(3))
15. *d* (par 2-2*e*(2))
16. *b* (par 3-2)
17. *b* (par 3-6*k*)
18. *c* (par 3-6*g*)
19. *c* (par 4-3*a*)
20. *a* (par 4-3*a*)

For further explanation, see Discussion.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

DISCUSSION

Exercise:

1. All paints, except water-thinned paints (d) are flammable. Most paints are quite safe, however, if simple precautions are followed.

2. All personnel should be in good health, but painters who are sensitive to toxic or skin irritating materials should work only with nonsensitizing paint, such as the water-thinned paints (a).

3. Chemical-cartridge respirator (d) is used for protection against fumes and solvent vapors. This type contains activated carbon cartridges which absorb the fumes or vapors.

4. Safety goggles must fit well, contain unbreakable glass or plastic lenses (d) and allow adequate peripheral as well as straight-ahead vision.

5. Safety helmets are worn when painters are working with abrasive blasting (a) media.

6. Cuffs, tears, or rips, loose pockets, loose ties and jewelry should be avoided because they are potential causes of accidents (b).

7. Personnel should never work alone in a hazardous area. Two men (buddy system) (c) should be assigned to such jobs, and each should be visible to the other at all times during the painting operations.

8. By far, the most common and serious accidents are falls from a height or on the ground because of a loss of footing (d). Falling or moving objects are the next most serious hazard.

9. Do not use a stepladder over 10 feet (d) high. Never use one as a straight ladder. Never stand on the top platform.

10. Extension ladders should have a minimum overlap of 15% (c) for each section.

11. ¼ working length of the ladder (b) is the distance the foot of the ladder should be away from the wall.

12. Provide guard railings at any height (a), on the full length of the scaffold and also on the ends.

13. Flammable liquids and vapors (a), especially the latter, are by far the chief causes of fire and explosion.

14. Provide unit locks on all towers, and do not use casters less than 6 inches in diameter (d).

15. Use manila rope of at least ⅝ inch diameter (d) in boatswain chairs and lifelines. When handling materials with manila rope, use proper knots and hitches.

16. Every gallon of solvent in the spray paint will create more than 100 (b) gallons of potentially dangerous gas or vapor.

17. Use pails of sand (b), never sawdust, under dispensing pumps and spigots to absorb any spillage or overflow.

18. Wet down paint sweepings, rags and waste with water, and store in closed metal containers (c) until disposed of in an approved manner.

19. Methylene chloride (c) is the most common solvent used in nonflammable paint removers.

20. The milder solvents such as mineral spirits (a) are not as irritating to the skin as the stronger solvents listed in the other choices in the exercise.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 562 _____ Painting I.

LESSON 2 _____ Protective Coating Materials.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 562.

1. *a* (par 13-31)
2. *a* (par 8-35)
3. *c* (par 8-19)
4. *b* (par 14-12)
5. *d* (par 9-3)
6. *a* (par 12-50)
7. *c* (par 8-9)
8. *a* (par 12-37)
9. *b* (par 11-10)
10. *b* (par 14-2)
11. *c* (par 10-6)
12. *c* (par 12-3)
13. *a* (par 11-4)
14. *d* (par 14-8)
15. *d* (par 10-23)
16. *c* (par 13-23)
17. *b* (par 8-9)
18. *c* (par 11-26)
19. *c* (par 14-7)
20. *a* (par 11-12)

For further explanation, see Discussion.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

a. red lead primer and aluminum

b. zinc chromate and deck enamel

c. aluminum paint and water emulsion

d. red iron oxide and asphalt varnish

9. Which of the following would you select to provide a smooth, even finish on open-grain wood?

a. size

b. phenolic-resin primer-sealer

c. texture paint

d. wood filler

10. The label on a paint can states the color and type of paint and

a. viscosity

b. date of manufacture

c. consistency

d. blending characteristics

11. Tints are lighter than

a. shades
c. hues
b. tones
d. chromas

12. You are painting a previously painted wood surface that is in good condition. The primer is

a. added to undercoat

b. added to sealer

c. thinned

d. omitted

13. You are painting a wooden wall that has an absorbent surface. Which of the following would you apply before starting to paint?

a. shellac and alcohol

b. stain

c. aluminum pigment

d. zinc oxide

14. For best results the temperature of paint materials should be between

a. 40° F and 55° F

b. 50° F and 60° F

c. 60° F and 70° F

d. 65° F and 85° F

15. You want to mix 5 gallons of paint that contain a highly volatile thinner. What method do you use?

a. boxing
c. propeller
b. paddling
d. shaker

16. You must paint walk stripes in a building. These stripes must glow in the dark. Which of these do you use?

a. aluminum paint

b. highway yellow with glass beads

c. luminous paint

d. titanium dioxide

17. Zinc oxide is a desirable coating for the inside of a water tank because it

a. admits ultraviolet light

b. is nonpoisonous

c. is white

d. is fast drying

18. Which of the following would you use to apply joint cement to a sheetrock joint?

a. float
c. putty knife
b. chisel
d. screwdriver

19. In selecting a can of paint from the storeroom, you pick the one that

a. has lowest temperature

b. is on top of the stack

c. bears the oldest date

d. requires no stirring

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17. Zinc oxide has many desirable characteristics, but the fact that it is nonpoisonous (b) makes it especially acceptable for use on the inside of a water tank.

18. Joint cement is mixed with water until a thick paste is formed. It is normally applied with a broad putty knife (c) or a cement trowel.

19. Can that bears the oldest date (c) is used first. If date of manufacture is not shown on the can, the date of receipt is considered the approximate date of manufacture.

20. Zinc chromate (a) primer is generally used for metal surfaces, such as structural steel, bridges, tanks, refrigerators, railroad cars, motor vehicles, and aircraft.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 562 _____ Painting I.

LESSON 3 _____ Protective Coating Equipment.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 562.

1. *d* (par 15-41)
2. *b* (par 18-6)
3. *a* (par 15-7)
4. *d* (par 18-15)
5. *a* (par 15-30)
6. *c* (par 15-9)
7. *b* (par 16-57)
8. *d* (par 16-25)
9. *c* (par 16-38)
10. *d* (par 15-31)
11. *c* (par 15-22)
12. *a* (par 16-53)
13. *b* (par 16-17*b*)
14. *d* (par 17-15)
15. *a* (par 16-8)
16. *b* (par 15-25)
17. *c* (par 16-35)
18. *b* (par 15-12)
19. *d* (par 17-7)
20. *b* (par 16-32)

For further explanation, see Discussion.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

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DISCUSSION

Exercise:

1. The steam cleaner (d) uses a solution of detergent and water. Under high velocity, the vaporized spray loosens and removes dirt and incrustations.

2. It is good practice to have two or three sets of each size stencils on hand because many signs have two or three of the same letters (b) and it will save time if the complete sign can be made at one time.

3. Sharpen the chisel on a grinding wheel (a) by restoring the bevel, which is usually 60° to 70°. Sometimes it is necessary to remove the burrs from the head if the chisel has mushroomed.

4. The fountain stencil brush is equipped with a shutoff valve (d) between the reservoir and the brush to adjust the flow of stencil ink or to shut it off completely.

5. Reinforced abrasive wheels must be used on the portable power grinder and the safe operating speed that is indicated on the wheel blotter (a) must not be exceeded.

6. Aluminum oxide (c) with production paper backing is used on both wood and light metal surfaces. Its tough coating cuts faster and longer than the flints.

7. The sparking can result in explosion or fire. Be sure that you ground both gun and object (b) being sprayed. This can be done by attaching a static wire to ground.

8. Handles of the roller coaters accommodate a push-broom handle to permit painting floors without kneeling and to reach high places without using scaffolding (d).

9. The pressure-feed paint gun (c) is considered one of the best general-purpose guns for use with regular paints. Because no siphoning effect is necessary for pressure feed application, it is the tool for volume painting.

10. The descaler (d) is good for cleaning grooves, corners, rivets and protruding bolts and nuts. The needles can be interchanged with a chisel-like unit.

11. The vibrator sander (c) is an excellent tool for removing old paint and varnish and for sanding drywall joints.

12. If the engine has an oil filter, the filter cartridge is usually changed when the oil is renewed (a). The air filter is cleaned as recommended by the manufacturer.

13. Do not wipe the bristles on the edge of the container, as this wears them out or breaks them. Instead, the brush should be tapped against the inside of the container (b) above the paint level.

14. Glass spheres are embedded in traffic paint that is applied to curbs, lane markings, and runways. They reflect the light (d) at night.

15. A good quality brush has flagged bristles (a) to hold the paint and to spread it.

16. The drum sander (b) uses an abrasive belt, similar to the belt sander.

17. The suction spray gun (c) is ideal for small areas to be sprayed with lacquers, varnish, and other light materials.

18. Jeweler's rouge, rottenstone, and pumice stone (b) are three powdered abrasives used on furniture and fine woodwork to smooth the finishes between coats.

19. The width of the spray is governed by the distance the gun nozzle is from the surface being striped (d) and by the spray gun adjustments.

20. The bleeder (b) type spray does not build up excessive pressure in the compressor. If a spray gun is to be connected directly to a small compressor, it should be the bleeder type.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 562 _____ Painting I.

LESSON 4 _____ Ladders, Scaffolding and Metal Corrosion.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 562.

1. *b* (par 19-8 and fig 93)
2. *c* (par 21-13)
3. *c* (par 19-14)
4. *b* (par 20-14*c*)
5. *a* (par 19-5)
6. *d* (par 21-4)
7. *d* (par 21-7)
8. *c* (par 20-14*b*)
9. *b* (par 19-15)
10. *b* (par 20-6)
11. *d* (par 25-18)
12. *a* (par 22-6)
13. *c* (par 24-10)
14. *a* (par 22-15)
15. *a* (par 24-12)
16. *a* (par 22-4)
17. *d* (par 25-1)
18. *b* (par 25-12)
19. *c* (par 23-7)
20. *c* (par 23-4)

For further explanation, see Discussion.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

DISCUSSION

Exercise:

1. Extension ladders can be adjusted to various lengths by pulling on the rope which is threaded through the pulley (Figure 93) in a block and tackle (b) arrangement.

2. Hoisting machines that are on scaffolds have a lock and brake which are controlled by the painter. Before leaving the machine the painter must remove control handle and lock the brake (c).

3. Ladders not in use should be hung on brackets by the side rails in order to prevent warping (c).

4. Swing stage scaffolds erected but not in use should be lowered to the ground (b) for safety reasons.

5. As soon as you have the ladder in a perpendicular position, pull the bottom of the ladder out from the wall to a distance of ¼ the length of the ladder — $24' \times \frac{1}{4} = 6'$ (a).

6. The bowline (d) is used to form a loop in the end of a rope that will not slip and that is easily untied. Figure 108 shows how to tie a bowline knot.

7. The rolling hitch (d) is used to lower a load slowly. The workman can lower himself by releasing the pull on the fall line and rolling the knot. Figure 109 shows how to tie this knot.

8. A safety rule that must be followed while you use the swing stage scaffold is to lash the swing stage to the building (c) as soon as possible after hoisting so that it cannot swing outward.

9. A safety precaution in using ladders is never to allow anyone on the ladder with you. If you need help to do the work, tell your helper to get another ladder (b) for his own use.

10. The height of the tower must not exceed four times the smallest base dimension ($4 \times 4 = 16$) (b).

11. Acid spot tests (d) are based on the formation of characteristic colors produced by the reaction of the acid on the metal surface. The color reactions for many metals are listed in pars 25-20 and 25-21.

12. Corrosive attacks begin on the surface (a). There will always be evidence on the surface when an attack is in progress.

13. The galvanic anode (c) method of cathodic protection uses an electrode, which is referred to as a sacrificial anode, to protect a structure.

14. A good example of stress corrosion (a) is the use of cold-worked rivets to join steel sheets. The rivets carry an internal strain which makes them anodic to the steel.

15. With the impressed-current method of protection, a source of alternating current (a) is required. In addition, a rectifier is needed to get the required direct-current potential.

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16. The four things that must be present are the electrolyte, conductor, cathode, metal anode (a), defined respectively as a continuous liquid path, a carrier of flowing electrons, a cause, and something that corrodes.

17. By misidentifying metal (d) you may waste your efforts, damage material, or cause corrosion.

18. If a metal cannot be positively identified by visual examination, the next step is to see if it is attracted by a magnet and to perform a spark test (b).

19. Direct-current circuits that pass in and out of an electrolyte are a direct cause of corrosion. This condition poses the greatest problem in the vicinity of electrical transportation system, electrified coal mines (c) or manufacturing plants where their direct-current distribution system requires a ground as a complete or partial circuit return.

20. The current leaves the pipe through the soil to the cinders and returns to the pipe. Severe corrosion occurs at the point where the current leaves the pipe (c).

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MEMORANDUM 562

PAINTING I

(MATERIALS AND EQUIPMENT)

U. S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA

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NRI 106

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PREFACE

The Army operates many installations throughout the world. Many of these installations are constructed by civilian contractors, but alterations, additions, and maintenance are performed by military personnel.

This first of two subcourses discusses in four lessons the following subject matter: safety, protective coating materials and equipment; ladders, scaffolds, and hoisting equipment; and metal identification and corrosion control.

A good way to study material is to scan each chapter quickly. Scan the chapter headings and make a quick check to see how the entire lesson relates to these headings. As you scan the material, look at the major headings, boldface, capitalized, or italicized words for content. Then read the text assignment through rapidly the first time. Next, go back and read for review, getting the material fixed in your mind; then work the lesson exercises.

You should have favorable study conditions in order to get the greatest advantage from a study session. Favorable study conditions include a properly arranged room, proper lighting and ventilation, comfortable seating arrangement, and the absence of distracting influences. Study at a regular time each day and for short periods of time, rather than for one long study session.

Keep this memorandum for your own use after you complete the course.

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CHAPTER 1

SAFETY

SECTION 1 – GENERAL

1-1. **Hazards.** Every painting assignment exposes maintenance personnel to conditions and situations that represent actual or potential danger to themselves and to others in the area. The frequent necessity to use toxic and flammable materials, pressurized equipment, ladders, scaffolding and rigging always presents a potential hazard. Hazards may also be inherent in the very nature of the environment, or caused through ignorance or carelessness of the operator. It is, therefore, extremely important to be aware of all potential hazards, since continuous and automatic precautionary measures will minimize the problem and improve both efficiency and morale of the painting crew.

1-2. *Paint Materials.* Most paint materials are hazardous to some degree. All, except water-thinned paints, are flammable; many are toxic and others can irritate the skin. However, most paints are quite safe if simple precautions are followed.

1-3. *Surface Preparation Materials.* Preparing a surface for painting often requires the use of solvent, acid, or alkali cleaners. All of these will harm the skin unless used with care. Paint removers are also very irritating to the skin. The use of high pressure abrasive or water blasting methods may be hazardous. Pressures as low as 10–15 PSI have been known to cause serious injuries. In addition, carelessness during abrasive blasting operations may result in lung disease after continued exposure. Steam cleaning procedures employ high heat and pressure, both very hazardous to the operator and personnel nearby if not properly handled.

1-4. *Equipment.* Ladders, scaffolding and rigging must be used for areas which are not readily accessible from the floor or ground. Pressure equipment is used to prepare surfaces and to apply paint. All of this equipment can be extremely hazardous if handled carelessly. The proper setting up and dismantling of equipment, the required safety checks and the basic precautions in handling equipment, may require more time than their actual use. Nevertheless, precautions should not be omitted on the basis that risk decreases in proportion to time of use.

1-5. *Environment.* Painting conditions vary from job to job. One obviously hazardous location is the interior of a tank. However, painting the interior of a small room or closet may be more hazardous, since often no special precautions are taken and ventilation may be inadequate. Furthermore, the painter may encounter other hazards that exist in the area in which he is working in addition to the hazards inherent in the painting operation. For example, slippery floors or obstacles located on the floor may cause falls. Electrical or mechanical equipment may produce shocks or other serious injuries. Uninsulated steam lines or hot pipes may cause severe burns or too rapid evaporation of solvent thus creating a toxic hazard.

1-6. *Painting Crew.* Lack of training, experience or knowledge of hazards on the part of any painter produces a possible threat to the safety of the crew and others in the painting area. An element of risk is present even when well trained workers follow all prescribed safety procedures. Proper precautions will reduce this risk to a minimum, but no safeguard can guarantee protection against ignorance. Carelessness of

even a trained painter will also increase hazards tremendously. Deviation from established procedures by taking "short cuts" often produces unsafe working conditions resulting in accidents with consequent loss of time and materials, and, of greatest concern, human suffering.

1-7. *Degree of Hazard.* The risks involved vary from job to job. Painting the interior of a home with water-thinned paints, for example, is much less of a hazard than painting a water tank 100 feet above the ground. The foreman must be responsible for taking the special precautions, designating the equipment required and advising his crew of the specific hazards for each job. However, the painter should never forget that hazards exist in every job, though they vary in degree. To ignore hazards in any job is to increase the odds that accidents will occur. Relaxing of precautions in one job will inevitably lead to carelessness in all jobs, regardless of the degree of hazard. Thus habits are formed which will eventually result in an unnecessary increase in the accident rate.

1-8. **Safety Measures.** The potential hazards present in all painting operations make a continuing and enforced safety program absolutely essential. Adequate safety procedures will provide protection against the three major types of hazards, namely, accidents, fire and those to health. All personnel must be thoroughly familiar with safety rules. Each worker is responsible for adhering to all established precautionary programs for his own protection as well as that of others. Disregarding safety measures will increase potential dangers and the odds that an accident will occur. See Corps of Engineers Manual EM 385-1-1 "General Safety Requirements", Department of the Navy Manual NAVSO P-2455 "Safety Precautions for Shore Activities" and Air Force Handbook AFM 127-101 "Accident Prevention". Also see MIL-STD-1212, "Industrial Safety Belts and Straps".

1-9. *General Health.* All personnel should be in good health. Painters who are sensitive to toxic or skin-irritating materials should only work with non-sensitive paint materials such as water-thinned paints. Any worker sensitive to heights should not work on ladders, scaffolding, or rigging. Personnel who have an improper attitude towards safety should not be allowed in painting crews.

1-10. *Environment.* Study the working environment before sending painters into any work area. Look for hazards such as poor ventilation and noxious fumes. Before a painter is allowed to enter such an area, he must be protected by devices that will allow him to work in safety. If ventilation is required, then outside air should be provided at a minimum rate of 15 cubic feet of air per minute per person or 1½ changes per hour, whichever is greater. Otherwise respiratory protective equipment should be provided. If exhaust systems are used, such as in a tank, for example, the system must take suction from the bottom of the tank or a similar area in which the work is being done. Never work alone in a hazardous area (see 1-14.). The discharge from exhaust systems must be arranged so that contaminated air will not create a health hazard in surrounding areas. Temperatures should be kept at 65°F to 75°F, if possible.

1-11 *Respiratory Protection.* Personnel must wear the proper type of face mask in hazardous areas. All must be devices approved by the United States Bureau of Mines. The most important types of respirators are as follows:

a. Dispersoid respirators for protection against dusts as are present when sanding. These respirators contain filters only. (See Figure 1.)

b. Chemical cartridge respirators for protection against fumes and solvent vapors. These respirators contain activated carbon cartridges which absorb the fumes or vapors. (See Figure 2.)

c. Supplied air respirators for use in closed areas where ventilation cannot be supplied. (See Figure 3.) Fresh air blowers of the positive pressure type, Bureau of Mines approved, shall be provided for each two respirators and the hoses limited to 150 feet.

d. Abrasive blasting helmets for use when blast cleaning surfaces to be painted. (See Figure 4.)

See Department of the Army Technical Bulletin TB MED 223 and Department of the Air Force Pamphlet AFP–161–1 "Respiratory Protective Devices", also Department of the Navy NAVDOCKS P–342 "Fuel Storage Tank Cleaning at the Shore Establishment". The life or health of the wearer may depend on the availability and proper functioning of respiratory equipment. They must be cleaned immediately after use and be properly maintained and stored in clean, dry compartments. Filters, cartridges, and rubber parts should be inspected before each use, and at regular intervals, for any signs of deterioration. Replace any suspect filter or cartridge immediately.

1-12. *Eye Protection.* Safety goggles must be worn in areas where there is any possibility of dust, fumes or solvents touching the eyes as may occur when blasting, sanding, or spraying. They must be kept clean and readily available. They should fit well, contain lenses of unbreakable glass or plastic, and allow adequate peripheral as well as straight ahead vision. (See Figures 5, 6.)

Figure 2. Chemical Cartridge Respirator.

Figure 1. Mechanical Filter Respirator.

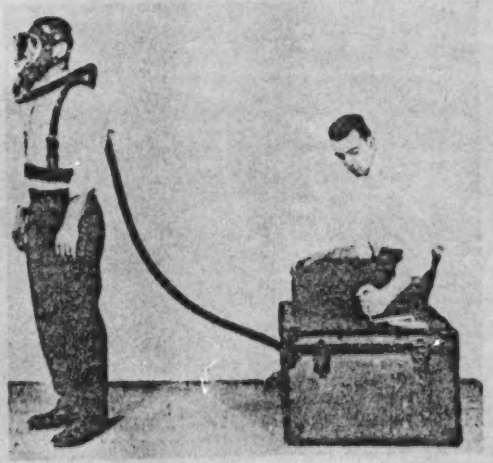

Figure 3. Supplied Air Respirator.

1-13. *Protective Clothing.* Personnel should wear clean clothing covering them as much as possible to avoid skin contact with painting or cleaning materials. Cuffs, tears or rips, loose pockets, loose ties and jewelry should be avoided since they are potential causes of accidents. Safety helmets should be worn when using abrasive blasting media. (See Figure 4.) Hard hats and steel toed safety shoes should be worn wherever there is any possibility of danger from falling objects. Shoes should have non-skid rubber soles when working in enclosed spaces or where flammable vapors may be present. Acid-proof clothing should be worn when handling acid cleaners. Use acid-proof air-supplied suits when using acid cleaning materials in enclosed areas. (See Figures 7 thru 10.)

1-14. *Buddy System.* Personnel should never work alone in hazardous areas. At least two men should be assigned to such jobs, and each should be visible to the other at all times during the painting operations. Then, if one should have an accident, the other can immediately come to his aid.

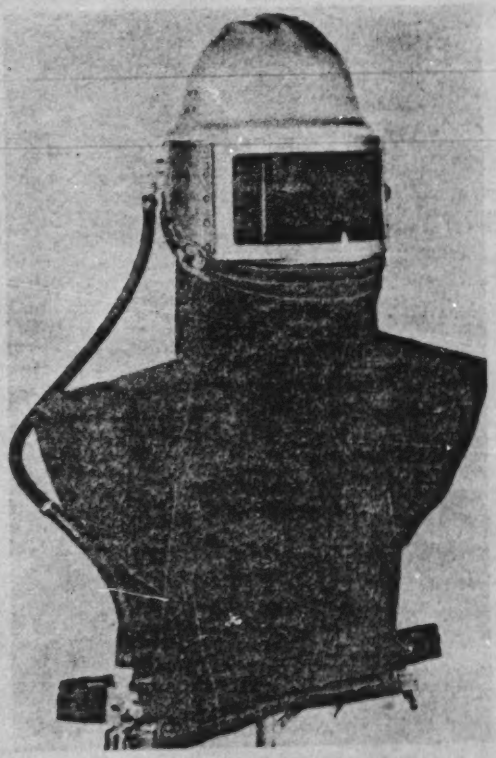

Figure 4. Abrasive Blasting Helmet.

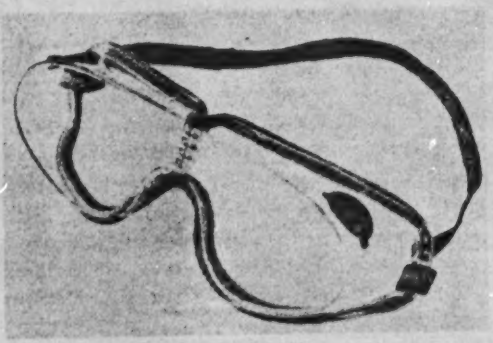

Figure 5. Safety Goggles.

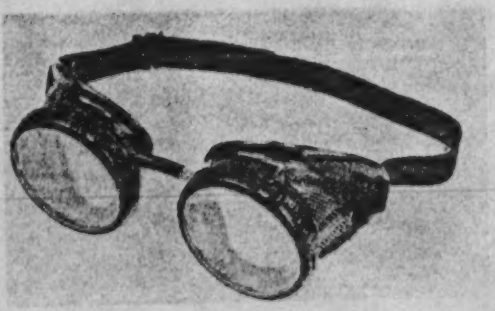

Figure 6. Safety Goggles.

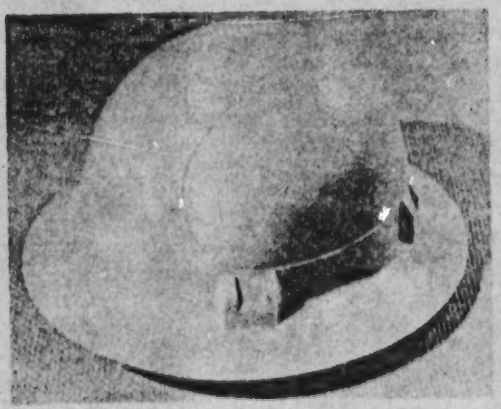

Figure 7. Hard Hat.

1-15. **Responsibility of Foremen.** The foreman should lay out the work and manage projects in such a manner as to produce the safest possible conditions. Safety of personnel is one of his prime responsibilities. A safety check-off list as illustrated in Figure 11 should be used by the foreman before a job gets underway. In addition all foremen should adhere to the following program:

a. Always be aware of potential hazards in the area.

b. Be sure that each painter understands and accepts his personal responsibility for safety and that he is informed of all safety rules.

c. Be sure that all safety measures have been taken each day before any job is started.

d. Insist that the men work safely. Use disciplinary action in accordance with existing personnel directives, if necessary.

e. Be sure that all equipment meets safety standards. Use non-sparking tools in hazardous areas. Anticipate possible risks with new types of equipment. Secure expert advice on potential hazards *in advance*.

f. Encourage the men to discuss the hazards in their work. No job should proceed if any question about safety remains unanswered. Be receptive to their ideas and suggestions; these may be the best source of field experience that will prevent accidents.

g. Set a good example for the men by demonstrating safety in personal work and conduct.

Figure 8. Safety Shoes.

Figure 9. Acid-Proof Clothing.

Figure 10. Acid-Proof Air-Supplied Suit.

- ☐ "No Smoking" warnings
- ☐ Clothing
- ☐ Eye Protection
- ☐ Respiratory protection
- ☐ Safety Belts
- ☐ Warning tags and signs
- ☐ Toxic materials
- ☐ Burns to skin
- ☐ Falling objects
- ☐ Electrical hazards
- ☐ Footing
- ☐ Moving objects, cranes, traffic, etc.
- ☐ Safety showers and eye baths
- ☐ Fire alarm station
- ☐ Fire extinguishers, fire blankets
- ☐ Nearest telephone
- ☐ Barricades
- ☐ Equipment grounded
- ☐ Sparkproof tools
- ☐ Safety or fire permits
- ☐ Flammability or flash point
- ☐ Condition of ladders and scaffolding

Figure 11. Safety Check List.

SECTION 2 — ACCIDENT HAZARDS

2-1. **Causes.** Accidents during painting operations are caused by unsafe working equipment, unsafe working conditions and careless personnel. Any or several of the following can cause accidents:

a. Lack of knowledge, experience and training in the use of painting materials and equipment.

b. Improper maintenance and storage of equipment.

c. Failure to pre-check equipment for mechanical and structural flaws.

d. Improper use of equipment.

e. Failure to consider environmental conditions and existing hazards in work areas before, during and after painting operations.

f. Personal carelessness.

Accidents most frequently involve commonly used equipment. The most common and serious accidents, by far, are falls either from a height or on the ground because of a loss of footing. Falling or moving objects are the next most serious hazard.

2-2. **Precautions and Prevention.** Nothing should be taken for granted. Proper use of equipment must be taught to all personnel by

qualified operators. Refresher courses on the use of all equipment must be regularly scheduled.

2-3. *Equipment Check And Use.* The following basic procedures in setting up and use of equipment are imperative to assure safety standards and maximum protection of all personnel.

a. *Ladders:*

(1) Store wood ladders in a warm, dry area protected from the weather and ground.

(2) Protect wood ladders with clear coatings only, so that cracks, splinters or other defects will be readily visible.

(3) Inspect all ladders frequently for loose or bent parts, cracks, breaks or splinters.

(4) All straight and extension ladders must have safety shoes. These should be of insulating material for metal ladders. (See Figure 12.)

(5) Do not use portable ladders greater in length than can be readily carried and placed by two men. Never splice ladders to form a longer ladder.

(6) Pre-test all ladders and scaffolding before use by placing horizontally with blocks under ends and "bouncing" in the center or walking along ladder or scaffold.

(7) Extension ladders should have a minimum overlap of 15% for each section. (See Figure 13.)

(8) Do not use stepladders over 10 feet high. Never use one as a straight ladder. Never stand on the top platform.

(9) Place ladders so that the horizontal distance from the top support to foot is at least ¼ of the working length. Be sure that the ladder is securely in place. Rope off all doorways in front of the ladder and place warning signs. (See Figure 13.)

(10) Use hand lines to raise or lower tools and materials. Do not overreach when working on ladders. Move the ladder instead.

(11) Never use metal ladders in areas where contact with electric power lines is possible.

Note: The use of portable metal ladders is not recommended by the Navy until a satisfactory specification is approved by the Navy Department (NAVSO P-2455).

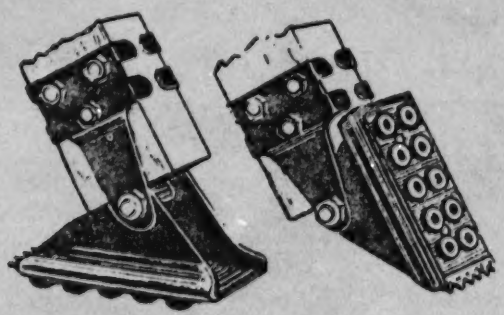

Figure 12. Ladder Safety Shoes.

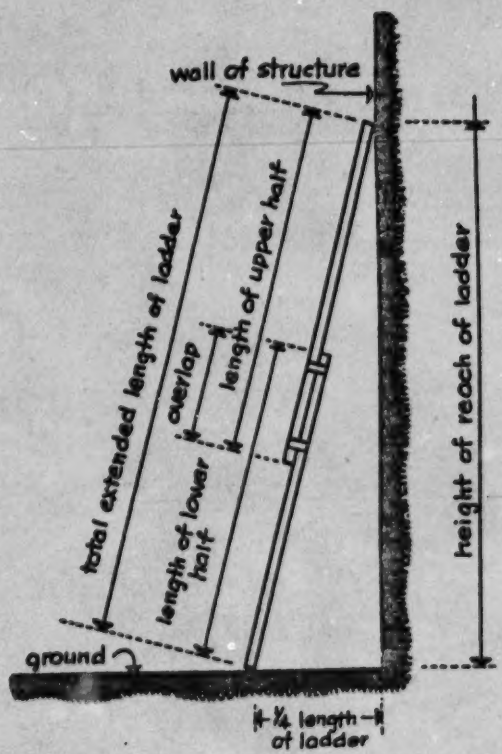

Figure 13. Ladder Stability.

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b. *Scaffolding (See Figures 14 thru 21 for types of scaffolding):*

(1) Inspect all parts before use. Reject metal parts damaged by corrosion and wood parts with defects such as checks, splits, unsound knots and decay.

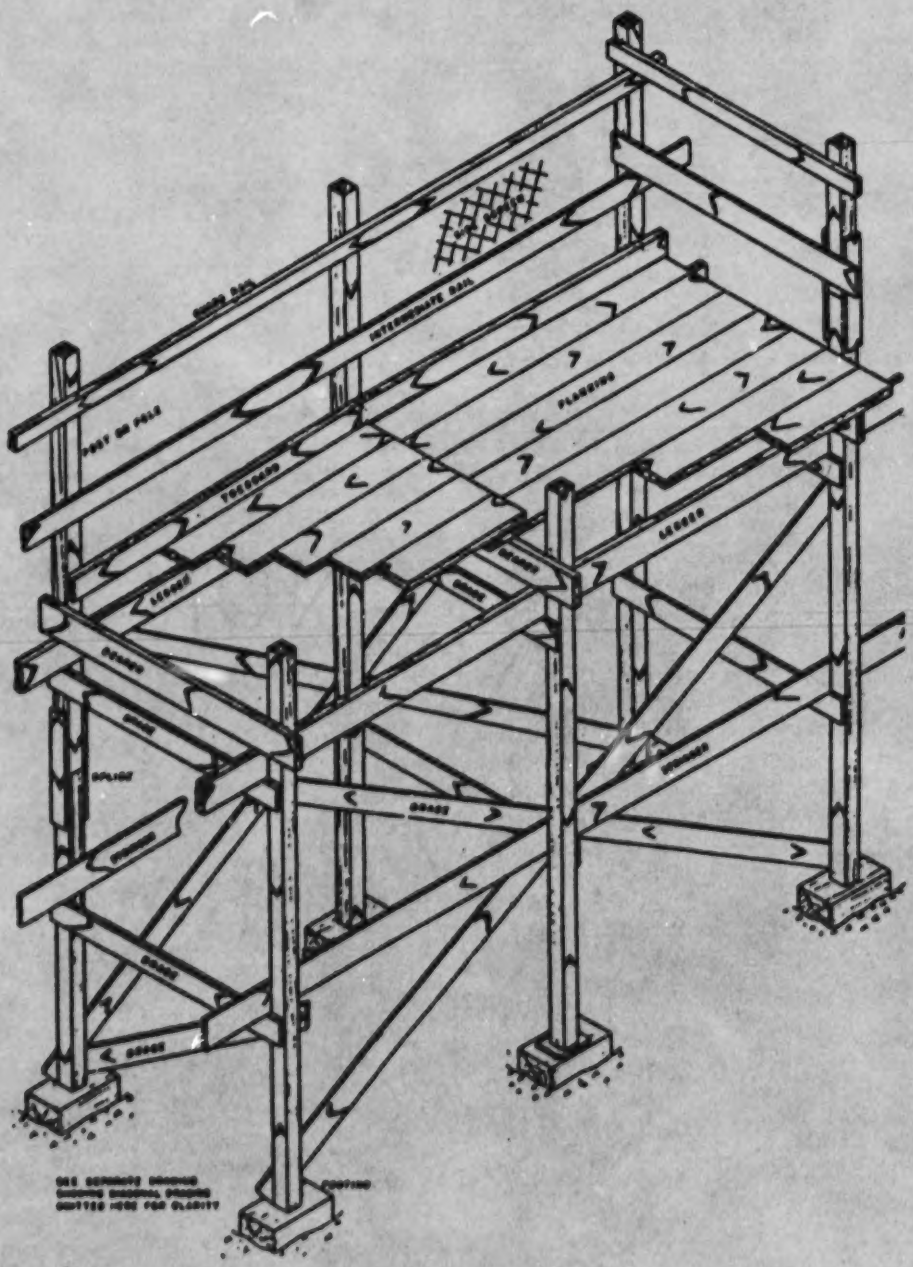

Figure 14. Double Pole or Independent Scaffolding.

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(2) Provide adequate sills or underpinnings when erecting on filled or soft ground. Be sure that scaffolds are plumb and level. Compensate for uneveness of the ground by blocking or using adjusting screws.

(3) Anchor scaffolds to the wall about every 28 feet in length and 18 feet in height. Do not force braces to fit. Use horizontal diagonal bracing at bottom and at every 30 feet in height.

(4) Lumber should be straight grained. All nails should be driven full length and not subject to direct pull.

(5) Provide guard railings regardless of height, on the full length of the scaffold and also on the ends.

(6) Erect scaffolding so that ladders are lined up from top to bottom. Always use ladders when climbing scaffolding.

(7) Tubular pole scaffolds should be made of two inch O.D. galvanized steel tubing or other corrosion resistant metal of equal strength. They should be erected or dismantled by experienced personnel only.

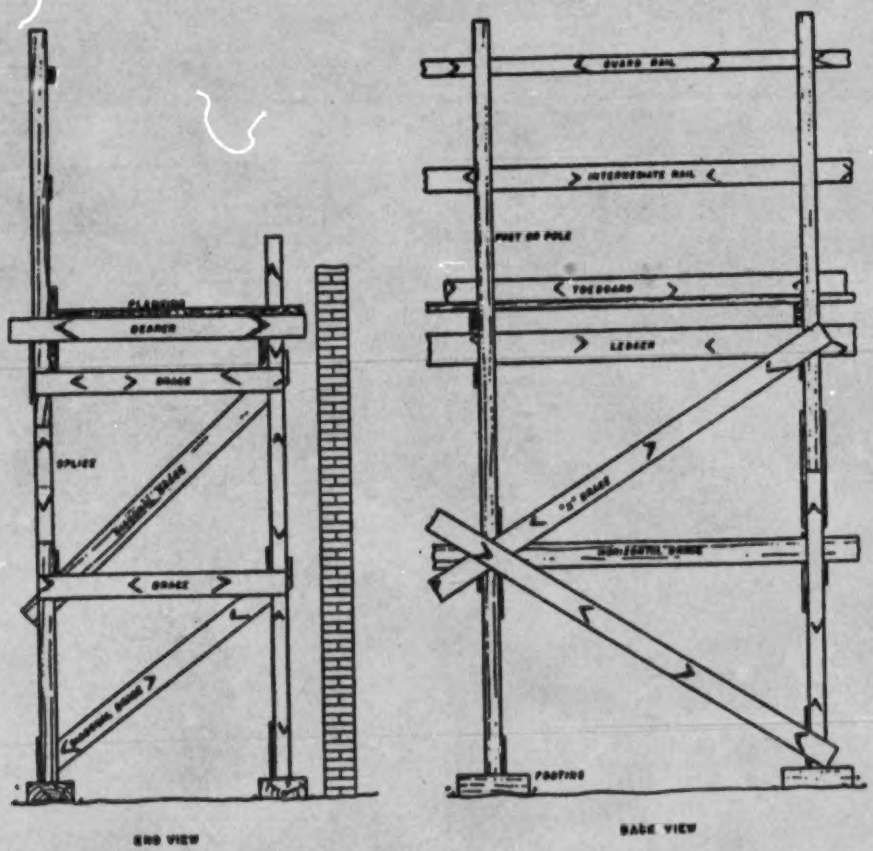

Figure 15. Diagonal Bracing on Double Pole Scaffolding.

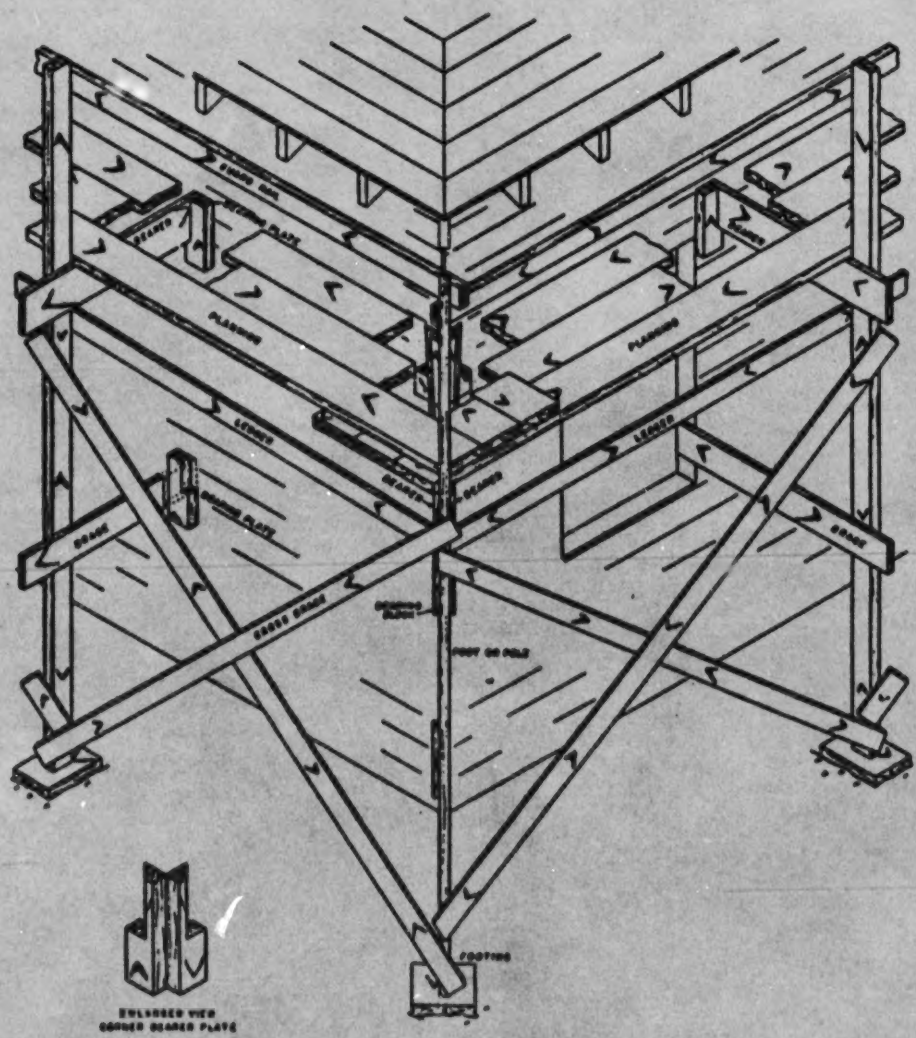

Figure 16. Single Pole Scaffolding-Corner Construction.

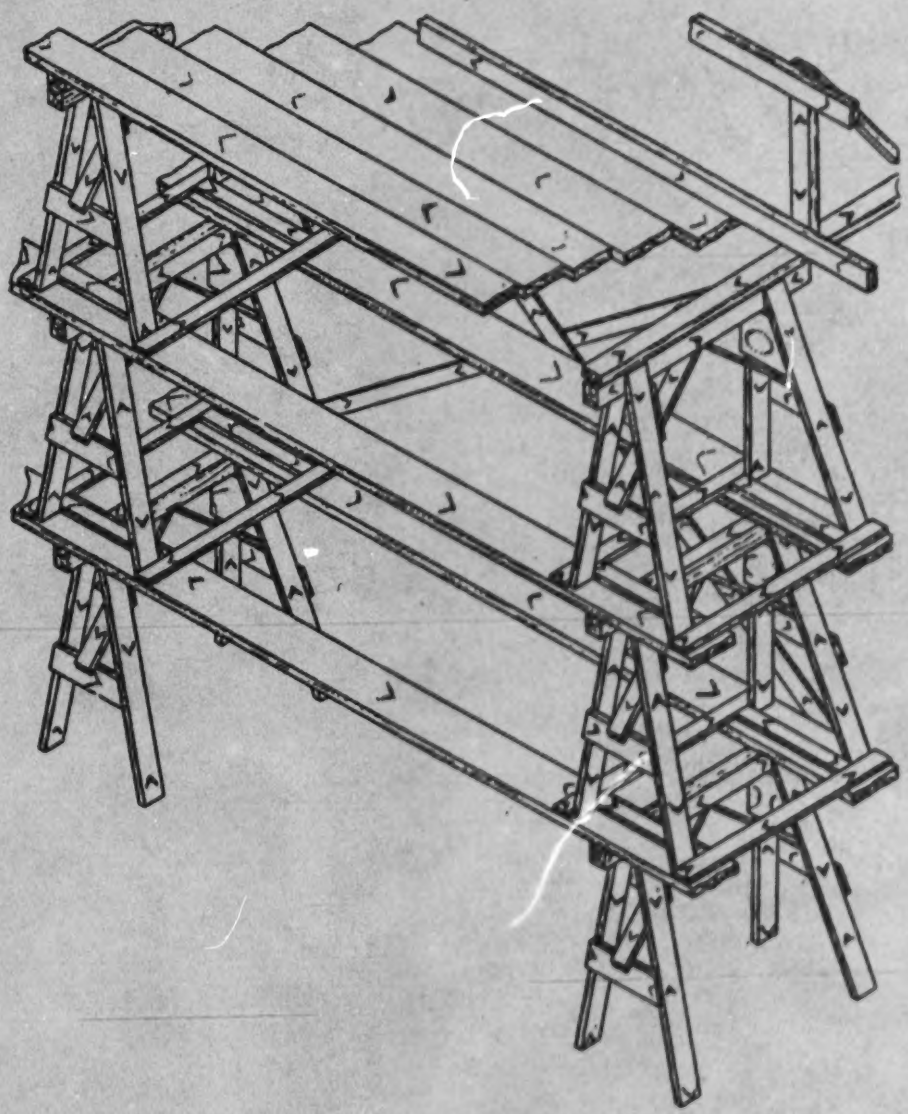

Figure 17. Horse Scaffold, Three Tiers (Max. Height 15 Ft.)

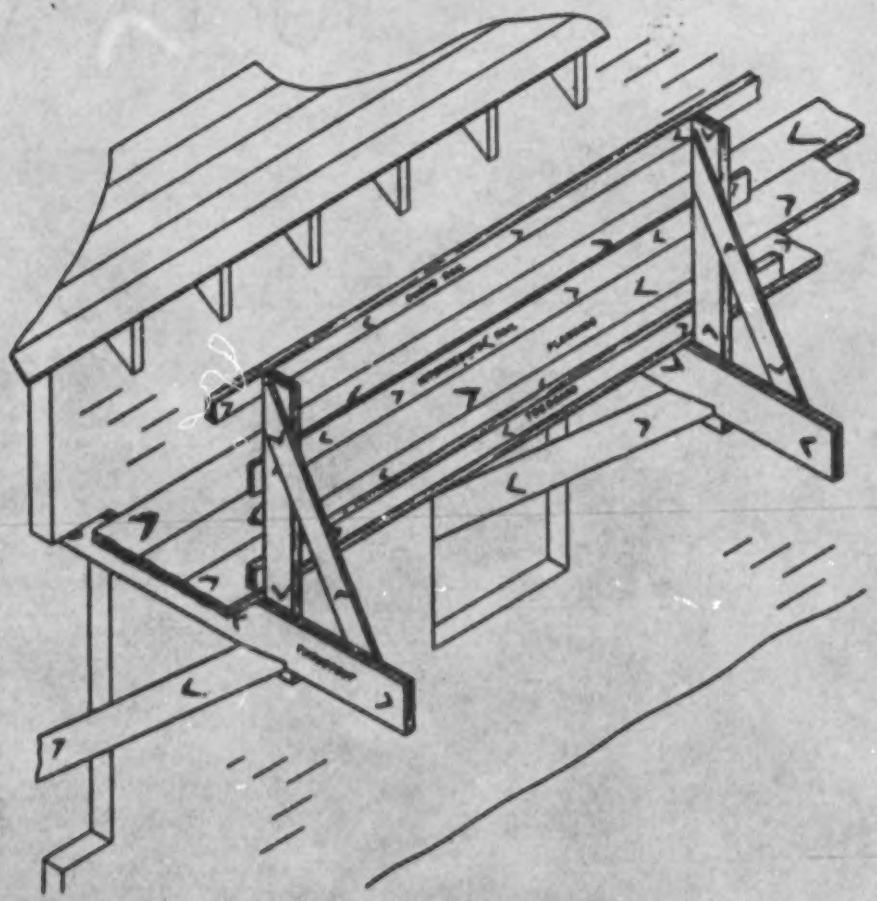

Figure 18. Outrigger Scaffold with Guard Rail.

Figure 19. Pipe Scaffolding.

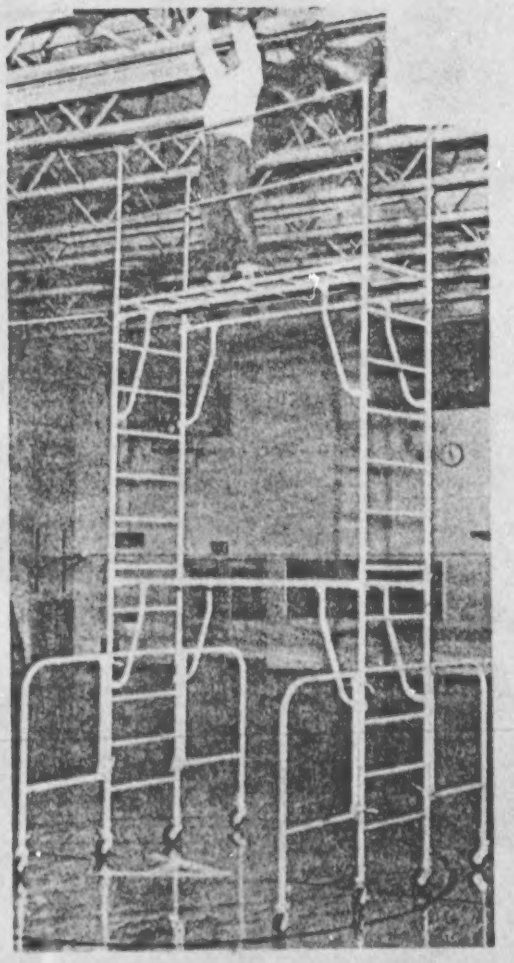

Figure 20. Pipe Scaffolding Roller Outrigger Type.

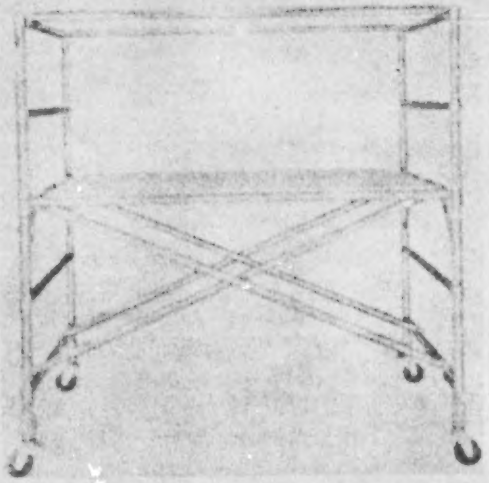

Figure 21. Pipe Scaffolding One Man Assembly Type.

(8) Planking should have at least a two foot overlap. Secure well to wood scaffolding. Platforms should be made of planking of uniform thickness laid close together. They must overlap and be fastened at supports. Do not use planking for other purposes; paint them only at the ends to identify them. Nominal sizes of planking should be determined from Table 1 below. Values are given in pounds for loads at center and allow for weight of planking.

(9) Test scaffolds and extensible planking (extended to working length) by raising them one foot off the ground and

Table 1. Safe Center Loads for Scaffold Plank

Span feet	*2 x 8**	*2 x 10**	*2 x 12**	*3 x 8**	*3 x 10**	*3 x 12**
6	200	255	310	525	665	805
8	150	190	230	390	500	605
10	120	155	185	315	400	485
12	100	130	155	235	335	405
14	—	110	135	225	285	346
16	—	—	115	195	250	305

Above values are for planks supported at the ends, wide side of plank face up, and with loads concentrated at the center of the span. For loads uniformly distributed on the wide surface throughout the length, the safe loads may be twice those given in the table. Loads given are net and do not include the weight of the plank. If select structural coast region Douglas fir, merchantable structural longleaf southern pine, or dense structural square edge sound southern pine are used, above loads may be increased 25 percent.

* Dressed sizes of planks, reading left to right, are: 1⅝ x 7½, 1⅝ x 9½, 1⅝ x 11½, 2⅝ x 7½, 2⅝ x 9½, 2⅝ x 11½, respectively.

loading them with weights at least 4 times the anticipated working load.

c. *Rolling Towers:*

(1) Inspect all tower parts before use. Do not use parts which are damaged by corrosion, deterioration, or misuse.

(2) Guy or tie off towers with heights more than three times the minimum base dimension, and fix towers at every 18 feet of elevation. Maintain stability of towers over 25 feet high with out-riggers or handling lines. Use horizontal diagonal bracing at bottom and at every height section.

(3) Provide unit lock arms on all towers. Do not use casters less than 6 inches in diameter. Do not extend adjusting screws more than 12 inches.

(4) Do not ride towers. Look where you are going when moving them. Do not attempt to move a tower without sufficient help. Apply all caster brakes when tower is stationary.

d. *Swinging Scaffolds, Swing Stages, Bosun Chairs. (See Figures 22 thru 24):*

(1) Always read instructions on the proper use and maintenance of the equipment. Follow prescribed load capacities.

(2) Stages should be at least 27 inches wide and supplied with guard rails (not rope).

(3) Only experienced personnel are to erect or operate stages. Check ropes and blocks before use by suspending stages one foot off the ground and loading at least 4 times the anticipated work load. Before locating on the job site, check for nearby electric power lines.

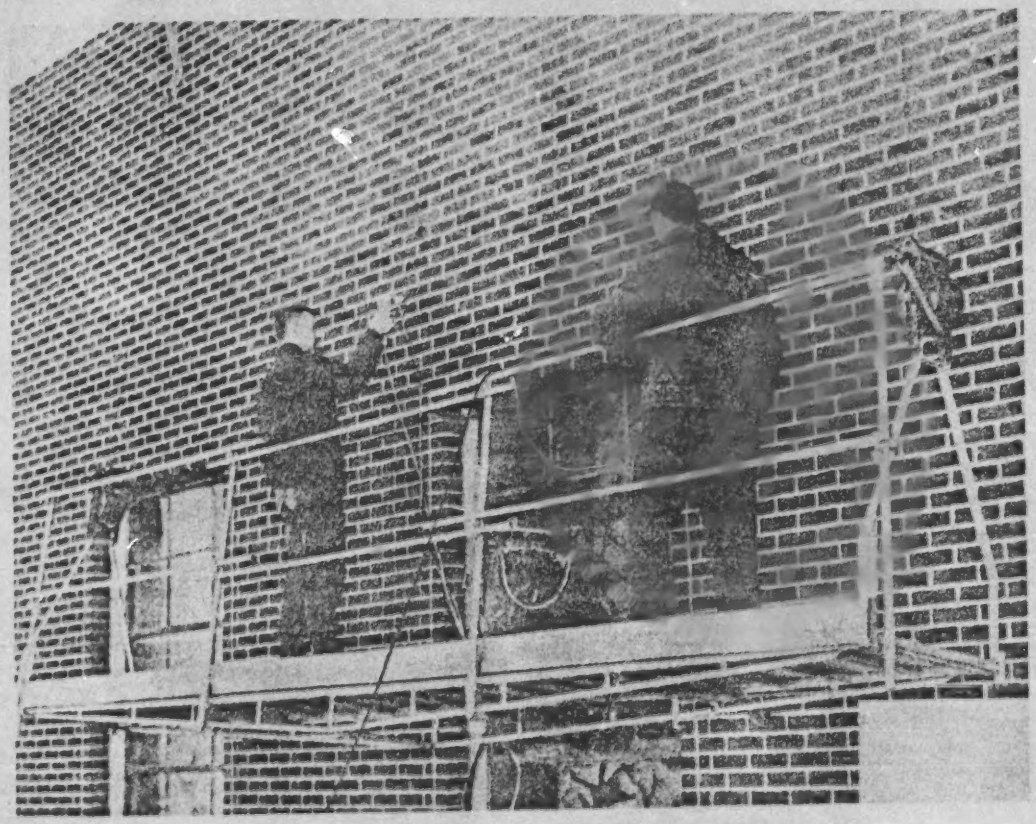

Figure 22. Swinging Scaffold Ladder Platform Type.

(4) Power stages should have free fall safety devices with hand controls in case of power failure.

e. *Ropes and Cables:*

(1) Store ropes and cables coiled in dry empty drums.

(2) Use wire rope at least ¾ inch diameter for platform slings; use manila rope at least ⅝ inch diameter in bosun chairs and life lines. Use proper clamps with wire rope, and proper knots and hitches when handling materials with manila rope. (See Figure 25.)

(3) Inspect ropes frequently. Discard if exposed to acid or excessive heat. Check for dry rot, brittleness or excessive wear. Never use frozen rope.

(4) Inspect all wire ropes and cables frequently in accordance with current service safety criteria.

(5) Do not attempt to salvage rope or cable by splicing.

Figure 23. Bosun Chair.

f. Pressurized Equipment: These rules apply to all types of equipment used both for spraying and blasting.

(1) Use only approved equipment. Use remote control deadman valves on high pressure equipment (60 lbs. or higher). These should be activated by the same air used for blasting or spraying. See Air Force Technical Orders T.O. 00-25-232N "High and Low Pressure Terminology" and T.O. 34Y1-1-171 "Hydrostatic Testing".

(2) Conduct a hydrostatic test at least once, preferably twice a year. Test safety relief valves daily.

(3) Use conductive hose. Ground nozzles, tanks and pressure equipment when in use, also object being sprayed. (See Figures 26 and 27.)

(4) Store hose in dry areas. When in use, avoid sharp bends, especially when curved around an object. Secure high pressure hose no more than 10 ft. from operator.

(5) Never point gun or nozzle at anyone or any part of the body. When handling or carrying, hold by the grip and remove the fingers from the trigger.

(6) Release all pressure before disconnecting any part of the equipment.

SECTION 3 — FIRE HAZARDS

3-1. **Causes.** Most paint products are highly flammable and extremely dangerous when they or their vapors are exposed to open flames, sparks or excessive temperatures. Flammable liquids and vapors, especially the latter, are, by far, the chief causes of fire and explosion.

3-2. *Solvents.* Most paint products are flammable because of the solvents they contain. These solvents are highly volatile, and some flash, in the presence of a flame, at temperatures below normal ambient painting temperatures. Thus, they may be safe in cold weather yet be potentially dangerous in midsummer. It is safer to use paint materials which will flash at temperatures significantly higher than painting temperatures since environmental changes can quickly change a safe condition to a dangerous one.

For example, mineral spirits, with a flash point of 105°F, is considerably safer to use than V M & P Naphtha (benzine) which has a flash point of 50°F or less. Furthermore, a paint, varnish or lacquer containing a mixture of solvents will flash at a temperature close to that of the most volatile solvent since this solvent vaporizes more quickly than the others. A low flashing paint material cannot be made safe by blending with another having a higher flash point. Since low flashing solvents volatilize or vaporize readily, they are most likely to bring about high concentrations of vapor in enclosed

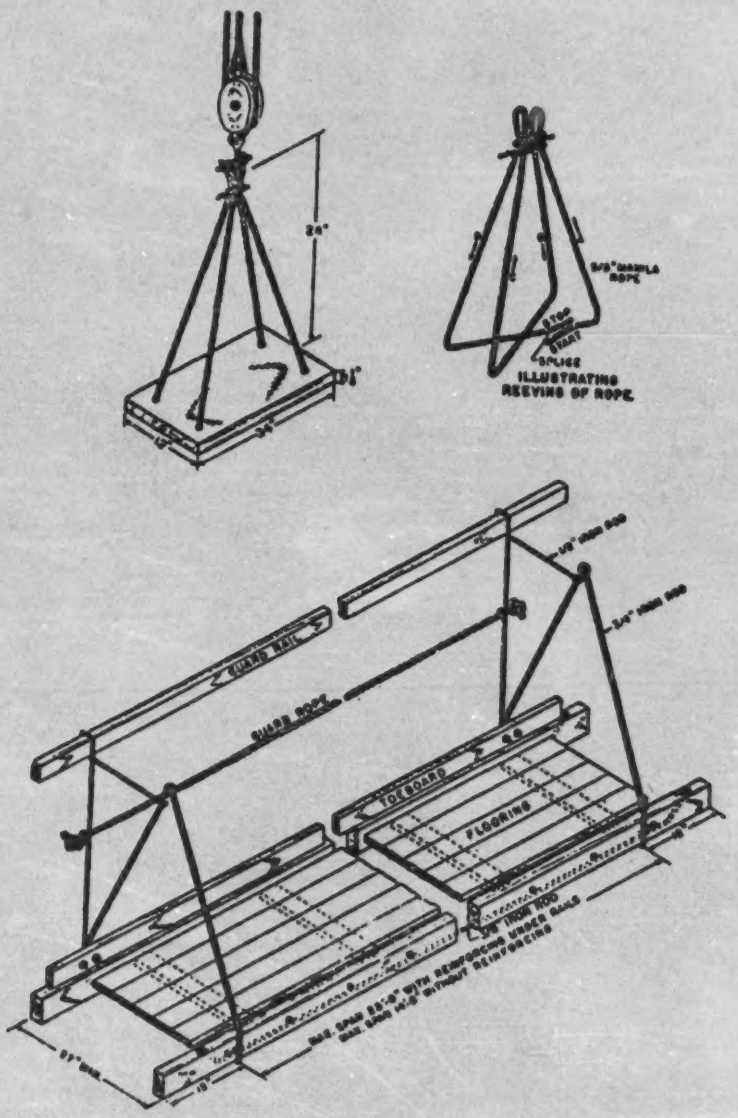

Figure 24. Bosun Chair and Swinging Scaffold (Construction Details).

spaces. This is especially true when spraying, since spray paints usually contain low flashing solvents to accelerate drying. A spray gun which applies a pint to a quart of paint per minute will cause a much greater concentration of vapor than a dozen brush painters. Every gallon of solvent in the paint will create more than 100 gallons of potentially dangerous gas or vapor. This condition is even more dangerous in confined spaces

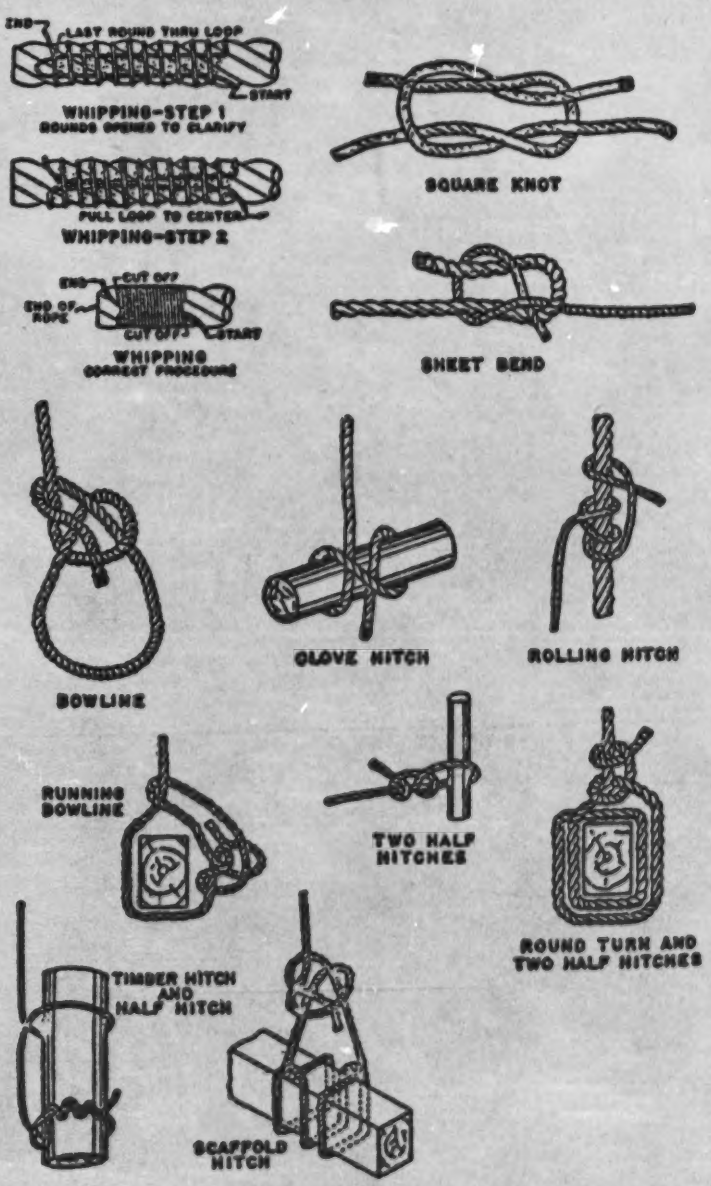

Figure 25. Knots and Hitches Used in Painting Operations.

since it is possible to cause an explosion, if a critical ratio of solvent vapor to air is reached, in the presence of a flame or spark. This is why spray equipment must be grounded to prevent ignition by a spark from static electricity. Furthermore, solvent vapors, which are heavier than air, will move along the ground for dozens of yards from the area of application. For this reason, all flames must be extinguished any where near the painting area. Flash points and flammable vapor/air limits of common paint solvents are given in Appendix C.

3-3. *Oil Paints.* Many exterior paints for wood and steel are based on raw or refined linseed oil. These represent a very definite fire hazard if paint-soaked waste or wiping rags are allowed to remain lying around. As the paint dries, the oxidation of the oil can cause the temperature to rise to the point where the rag or waste material will ignite spontaneously. The situation is especially dangerous with rags contaminated with pure raw or boiled linseed oil. (See Figure 28.)

3-4. *Other Paints.* The majority of paints applied on site contain high flash solvents (over 100°F), therefore, are relatively low in hazard and require only normal precautions. However, some finishes represent an abnormal fire and explosion hazard. Among these are spray finishes as described

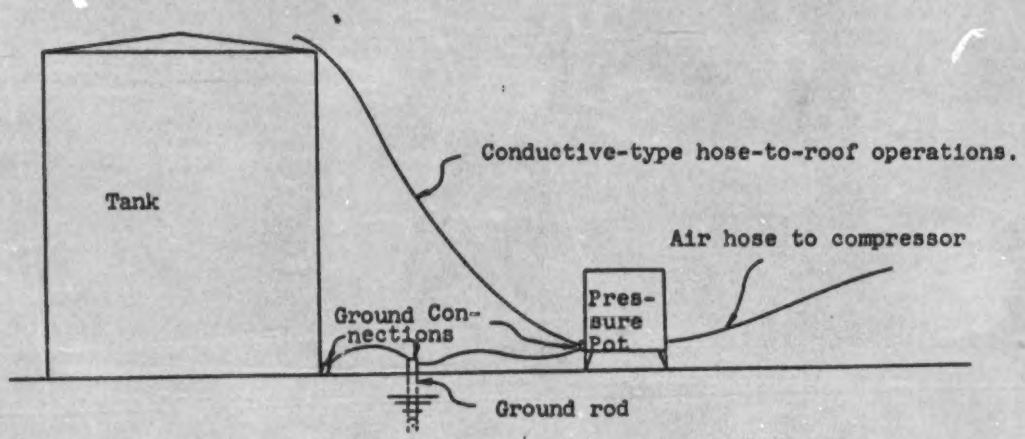

Figure 26. Grounding of Tank and Equipment.

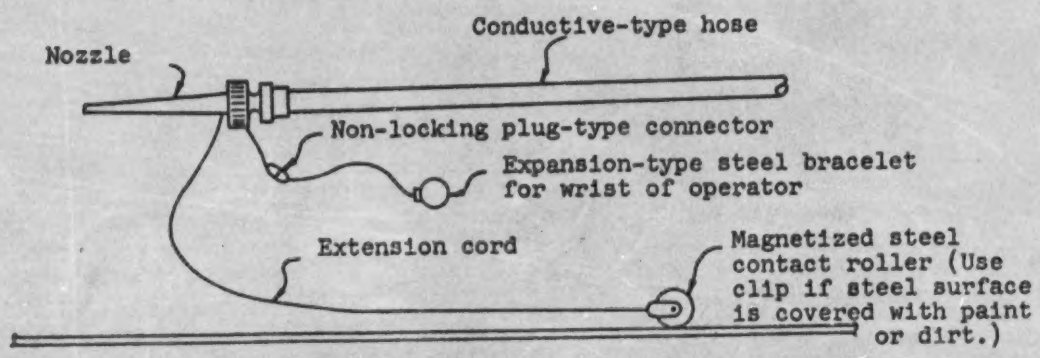

Figure 27. Grounding of Blast Nozzle.

Figure 28. Combustible Waste, Separate Containers.

in 3-2 because of the low flashing solvents used. Others are nitrocellulose lacquers which burn rapidly because of the nitrocellulose present, and two-component products which are subject to spontaneous combustion if mixed in large quantities.

3-5. **Precautions and Prevention.** Certain general rules regarding fire and explosion hazards apply to all situations. All paint materials should have complete label instructions which stipulate the potential fire hazards and precautions to be taken. Painters must be continuously advised and reminded of the fire hazards that exist under the particular conditions of each job, so that they will be aware of the dangers involved and assure that the necessary precautions are taken and maintained. Fire fighting equipment, of the proper type, must always be readily available in the paint shop, spray room and work areas where a potential fire hazard exists. Electric wiring and equipment installed or used in the paint shop, including storage room and spray room, must conform to the applicable requirements of the National Electrical Code for Hazardous Areas.

3-6. *Specific Safety Measures.*

a. Prohibit smoking anywhere that paint is either stored, prepared for use or applied.

b. Provide for adequate ventilation in all of these areas.

c. Perform recurrent spray operations on portable items, e.g., signs, in an approved spray booth equipped with adequate ventilation, a water wash system of fume removal and explosion proof electrical equipment.

d. Wet down spray booth surfaces before cleaning them.

e. Use rubber feet on metal ladders, and be certain that personnel working in hazardous areas use rubber soled shoes.

f. Use non-sparking scrapers and brushes to clean metal surfaces where fire hazards are present.

g. Wet down paint sweepings, rags and waste with water, and store in closed metal containers until disposed of in an approved manner. Do not burn in heaters or furnaces. (See Figure 29.)

h. Extinguish all pilot lights on water heaters, furnaces and other open flame equipment on all floors of the structure being painted. Be sure to turn the gas valve off.

i. When painting in confined areas near machinery or electrical equipment, open all switches and tag them to prevent their being turned on inadvertently.

j. Be sure that all mixers, pumps, motors, and lights used in the paint shop, spray room or on the job are explosion proof and electrically grounded.

k. Use pails of sand (never sawdust) near dispensing pumps and spigots to absorb any spillage or overflow.

l. During painting operations keep fire extinguishers nearby. Be sure that they are of the proper type. (See Table 2.)

Table 2. Use the Proper Fire Extinguisher

Choose from these 5 basic types of extinguishers	Three Classes of Fires		
	CLASS A FIRES Paper, wood, cloth, excelsior, rubbish, etc., where quenching and cooling effect of water is required.	CLASS B FIRES Burning liquids (gasoline oil, paints, cooking fats, etc.) where smothering action is required.	CLASS C FIRES Fires in live electrical equipment (motors, switches, appliances, etc.) where a non-conducting extinguishing agent is required.
CARBON DIOXIDE	Small surface fires only.	YES Excellent Carbon dioxide leaves no residue, does not affect equipment or foodstuffs.	YES Excellent Carbon doxide is a non-conductor, leaves no residue, will not damage equipment.
DRY CHEMICAL	Small surface fires only.	YES Excellent Chemical absorbs heat and releases smothering gas on fire; chemical shields operator from heat.	YES Excellent Chemical is a non-conductor; fog of dry chemical shields operator from heat.
WATER	YES Excellent Water saturates material and prevents rekindling.	NO Water will spread fire, not put it out.	NO Water, a conductor, should not be used on live electrical equipment.
FOAM	YES Excellent Foam has both smothering and wetting action.	YES Excellent Smothering blanket does not dissipate, floats on top of most spilled liquids.	NO Foam is a conductor and should never be used on live electrical equipment.
VAPORIZING LIQUID	Small surface fires only.	YES Releases heavy smothering gas on fire.	YES Liquid is a non-conductor and will not damage equipment.

m. Check ventilation and temperature regularly when working in confined areas.

n. Consult with electricians before painting in areas where high voltage lines and equipment are located.

o. Keep all work areas clear of obstructions.

p. Clean up before, during and after painting operations. Dispose of sweepings and waste daily.

SECTION 4 — HEALTH HAZARDS

4-1 **Causes.** A variety of ingredients used in the manufacture of paint materials are injurious to the human body in varying degrees. While the body can withstand nominal quantities of most of these poisons for relatively short periods of time, continuous or over exposure to them may have harmful effects. Furthermore, continued exposure to some may cause the body to become sensitized so that subsequent contact, even in small amounts, may cause an aggravated reaction. To this extent, these materials are a very definite threat to the normally healthy individual and a serious danger to persons with chronic illnesses or disorders. These materials are divided into two major groups, i.e., toxic materials and skin irritating materials.

4-2. *Toxicity.* Toxic materials may be present in the form of vapor, dust, or spray mist and may enter the body either

Fire Hazards!

Figure 29. Keep Combustible Materials in Metal Waste Cans Tightly Covered.

by breathing, swallowing or by absorption through the skin. Symptoms of excessive exposure can be irritation of the nasal membranes, headache, dizziness, loss of appetite, nausea and fatigue. Typical examples of toxic materials are as follows:

a. Pigments: The most common toxic pigments are lead-containing compounds and zinc chromate. Lead may be present in white or tinted paints as white lead; in primers as lead chromate, red lead, or basic lead silico chromate, and in paint driers. Refer to the specification for the analysis, and take proper precautions if the level of toxic pigment is greater than 1% of the total weight of solids in the dry paint film.

b. Solvents: The maximum allowable concentrations (threshold limit values) for the common paint solvents are listed in Appendix C. Among the most toxic solvents are benzol (benzene), methyl (wood) alcohol and chlorinated solvents, e.g., carbon tetrachloride. However, these solvents are rarely used in common paint materials.

c. Binders: Some binders or vehicles are toxic; for example: epoxies, amines, polyurethanes and polyesters. Avoid breathing fumes and spray or contact with skin. Wash hands and face thoroughly before eating or smoking.

4-3. *Dermatitis.* Dermatitic materials affect the skin. The skin becomes irritated and, if left untreated, infection can set in and progress to allergic sensitization and finally to incapacitation and hospitalization. Typical examples of dermatitic materials are:

a. Solvents: All solvents tend to remove natural oils and fats from the skin, leaving it dry, chapped, irritated, and sensitive to infection. The milder solvents, such as mineral spirits, are not as irritating to the skin as the stronger solvents such as turpentine, xylol (xylene), MEK (methyl ethyl ketone) or methylene chloride. (Methylene chloride is the most common solvent used in non-flammable paint removers.)

b. Resins and Resin Hardeners: Epoxy resins, amine hardeners, and some urethane and polyester resins irritate the skin and should be handled with special care.

4-4. *Other Hazardous Materials.* The following materials are also dangerous if handled carelessly:

a. Corrosive agents in paint removers and paint brush cleaners, e.g., phenol (carbolic acid).

b. Acid and alkaline cleaners; acid component of wash primer.

4-5. **Precautions and Prevention.** Health hazards can easily be avoided by a common sense approach of avoiding unnecessary contact with hazardous materials and by strict adherence to established safety measures. See

PORTABLE FIRE EXTINGUISHERS

Figure 30. Soda acid.

Soda-acid type extinguishers are used only on Class A fires. The use of the soda-acid extinguisher is also very simple. Simply direct the hose toward the base of the fire and invert the extinguisher. This inversion causes a mixing of the solution inside the tank, a reaction occurs, and the solution is supplied to the hose under pressure.

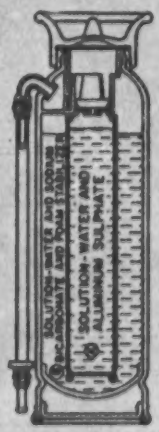

Figure 31. Foam.

The *foam* type fire extinguisher may be used either on Class A or Class B fires. The method of using this extinguisher is the same as for the soda-acid type. Invert it and direct the hose so that the foam is played over the surface of the fire. This is for a fire involving liquids. For a fire in a solid material the stream of foam should be directed to fall lightly on, or flow over, the burning surface of the material.

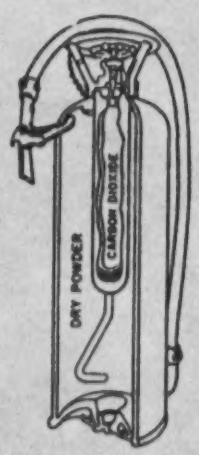

Figure 32. Dry chemical.

Dry chemical type extinguishers may be used on Class B and Class C fires. These units contain a dry powder, usually sodium bicarbonate, and an activating agent of CO_2 or nitrogen gas. These units should not be used on trash fires. To put the extinguisher into use, remove the locking pin, open the cartridge discharge valve, and squeeze the nozzle handle.

Figure 33. Carbon dioxide.

Carbon dioxide, or CO_2, type extinguishers may be used on Class B and on Class C fires. To operate the CO_2 extinguishers, pull the seal locking pin and open the operating valve. The CO_2 should be directed toward the base of the fire with a sweeping motion.

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Air Force Regulations AFR 161-10 "Precautionary Measures for Handling Solvents" and AFR 161-18 "Use of Potentially Toxic and Hazardous Materials".

4-6. *Specific Safety Measures.* The following rules should be strictly observed:

a. Toxic or dermatitic materials must be properly identified and kept tightly sealed when not in use.

b. Designate a competent person to check the operation of paint spray booths. Check at regular intervals to insure that the equipment is in a safe and proper operating condition.

c. Be sure that ventilation is adequate in all painting areas. Provide artificial ventilation where natural ventilation is inadequate. Use supplied air respirators, if necessary.

d. Spray all portable items within exhaust ventilated booths especially designed for that purpose.

e. Wear goggles and the proper type of respirator when spraying, blast cleaning or performing any operation where any abnormal amount of vapor, mist or dust is formed.

f. When handling dermatitic materials, use protective creams or preferably gloves, and wear appropriate clothing. Change and clean work clothing regularly.

g. Avoid touching any part of the body, especially the face, when handling dermatitic materials. Wash hands and face thoroughly before eating and at the end of the day.

SECTION 5 — EMERGENCIES

First Aid. First aid kits must be well stocked with fresh materials and be available and easily accessible during any painting operation. All personnel should be able to give emergency aid. However, any illness must be reported to the medical and industrial safety departments, regardless of whether or not it appears to be serious. Some toxic materials do not take full effect for days.

SECTION 6 — HEALTH SERVICES

6-1. **Medical Department.** The foreman must consult with the installation medical department regarding any questions or problems relating to the personal health and hygiene of the men assigned to him. Decisions in this area are to be made by the installation medical officer and must be strictly followed. Recommendations made by the medical department are to be presented to the painting crew and enforced by the foreman.

6-2. **Medical Examinations and Records.** All painting personnel are initially required to have thorough medical examinations with the results entered into their permanent record files. Subsequent examinations may be required periodically before personnel assigned to the painting crew can be exposed to any job or paint material considered to be at all hazardous. The foreman will also immediately request a medical examination of any person suspected of having an illness or affliction which may have been the result of painting operations, or which may be aggravated by intended painting operations.

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CHAPTER 2

Protective Coating Materials

WHY DO WE PAINT? What is the best protective coating to use? How can I do a professional job of painting? How can I mix the correct colors? How should I store protective coatings? These are questions that you, as a protective coating specialist, will probably ask yourself. By studying this chapter you should be able to answer them.

2. In the early days of America, paint was a symbol of prestige similar to the large car or huge yacht. The leading citizens always painted their homes white, and that painted home stood as a symbol of wealth. There's a legend that a lowly shoe cobbler painted his home and was subsequently tarred and feathered and run out of town. This wrongdoing made others in the colonies think and reminded them that all men should have the same privileges regardless of wealth.

3. Some of the colonists even went one step further in decorating; they discovered that red oxide of iron could be used to paint the trim red, which would brighten up their homes. After the discovery of copper ore, the colonies found that they could create green colors from this ore. Painting and development of colors progressed to the present day when almost any desired color can be mixed.

7. Purpose and Function of Protective Coatings

7-1. Why do we paint? At one time protective coatings were used primarily for beautification, then it was found that painting would preserve the wood and prevent rotting. The military uses paints to camouflage weapons and installations. A recent usage of paints is for identification purposes. The use and demand for protective coatings have grown until today over 5 billion dollars each year are spent on them. The military , along with other Government agencies and commercial establishments, uses a considerable quantity of these coatings for protection, sanitation and cleanliness, illumination and visibility, safety and efficiency, appearance, camouflage, and fire control.

7-2. **Protection.** Protection of the surface is the most important purpose of painting. If properly chosen and applied, paint will protect wooden buildings from moisture and sunlight, metal structures from corrosion, and concrete and masonry surfaces from the weather. Painting, when regularly programmed, offers long-range protection that extends the useful life of a structure.

7-3. **Sanitation and Cleanliness.** Paint and proper painting operations promote sanitation and cleanliness. Paint provides smooth, nonabsorptive surfaces that are easily washed and kept free of dirt. Such surfaces tend to keep foodstuffs from adhering. Adhering foodstuff harbors germs and causes disease. The coating of rough or porous areas seals out dust and grease that would otherwise be difficult to remove. Paint coatings will reveal buildup of foreign substances, indicating that better housekeeping practices are in order. Painting, therefore, is an essential part of general maintenance programs for hospitals, messhalls, offices, warehouses, and living quarters.

7-4. **Illumination and Visibility.** White and light-tinted paints applied to ceilings and walls reflect both natural and artificial light and help brighten rooms and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat paints diffuse, soften and evenly distribute illumination, whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility of the painted surface, especially when the paint is applied in distinctive patterns. For example, white on black, white on orange, or yellow on black can be seen at greater distances than single colors or other combinations of colors.

7-5. **Safety and Efficiency.** A recent innovation in the use of paints is the identification of pipes carrying different material such as oil, steam, water, and air through a hangar or industrial plant. It is also used to indicate hazards

or danger areas by using various colors. This area usage of paints is expanding at a very rapid pace, especially in schools, hospitals, other institutions, and industrial plants.

7-6. **Appearance.** Painting is primarily used for maintenance and to improve safety and efficiency. Decorative painting is sometimes considered to be secondary in importance and is therefore kept at a minimum. However, the functional use of color does create comfortable living and working conditions and more pleasant surroundings that result in improved morale and increased efficiency.

7-7. **Camouflage.** Paint is used by military forces to camouflage weapons and installations against enemy detection. By expert application of colors that blend with the surrounding terrain, it is difficult for the enemy to detect the locations of weapons, supplies, buildings, or even ships from the air.

7-8. **Fire Retardance.** Certain paints delay the spread of fire and assist in confining it to its origin. This allows more time during which fire-fighting equipment can arrive to extinguish the blaze before it gets out of control. The use of fire-retardant paints is restricted to appreciable areas of highly combustible surfaces and for selected uses. Their use is further restricted to interior surfaces except for Arctic areas. Fire-retardant paints must not be considered as substitutes for conventional paints as their cost is much higher.

8. Composition of Protective Coatings

8-1. To select the best protective coating for a given surface, it is important that you understand the composition of coatings. The principal ingredients of paints are the pigments and the vehicle. The pigment is the part of the paint that constitutes the solids and the vehicle is the fluid. Many types of materials used in the formulation of paints are far too numerous to permit the inclusion of a description of each in this chapter; however, in order to acquaint you with the most common paint pigments and vehicles, they are discussed as a class, and in some instances, the more important materials in a class are described.

8-2. **Pigments.** The pigments are fine solid particles used in the preparation of paint which are insoluble in the paint vehicle. Pigments are available in two forms, powder and paste, the latter being ground in oil, Japan, or other vehicle to a stiff consistency. There are five main types of pigments: white pigments, color pigments, metallic pigments, black pigments, and extender pigments.

8-3. *White pigments.* White pigments are of great importance to the paint industry because white is a widely used color and serves as the base for popular pastel colors. The most common white pigments used are titanium dioxide, white lead, antimony oxide, and zinc oxide.

8-4. Titanium dioxide has been available for pigment since 1932. It has a definite advantage where maximum hiding is required. Titanium dioxide has overshadowed all other white pigments because of its "chalking" ability. This means that the surface becomes chalky and can be rubbed or washed off. This is an obvious advantage in white or light-colored house paints because rain will wash away the chalk, and along with it goes the dirt and grime, leaving a clean, bright surface. It is a disadvantage with dark colors because it gives a fading appearance of the color.

8-5. White lead, a component of almost all white and light-colored paints, is one of the most important and oldest of the white pigments. There are two kinds: the basic lead carbonate and basic lead sulfate.

8-6. Basic lead carbonate combines readily with linseed oil and makes a smooth and easily brushed paint. It has a peculiar drying quality within itself which reacts with the linseed oil to facilitate drying. It also has the characteristics of gradual chalking, which causes the paint film to lose its gloss and wear away in a fine powdery form. Slow chalking is desirable in any paint, since the action provides a good surface for repainting without too much preparation.

8-7. Basic lead sulfate, sometimes called sublimated white lead, has approximately the same hiding power as basic lead carbonate, and in most cases may be substituted. Lead sulfate is usually considered less durable than lead carbonate and is usually less expensive.

8-8. Antimony oxide is used chiefly in the coating industry in the manufacture of fire-retardant paints, where it is used in combination with chlorinated materials and calcium carbonate. The Navy uses paints with this type of pigment on interior surfaces of its ships.

8-9. Zinc oxide is one of the finest of all white pigments and actually one of the whitest. It is opaque to ultraviolet light and, when incorporated in a paint, protects the film from the destructive action of the ultraviolet rays in sunlight. While zinc oxide contributes to the hiding power of paint, some of its other properties are more important. It is not discolored by the sulphur gases in the atmosphere. It is nonpoisonous. Zinc oxide is used as a preventive for mildewing or yellowing and also adds hardness to a paint film.

It is a valuable pigment for controlling checking and chalking and dirt retention of exterior paint films. It is also used in metal protective paints for rust inhibition, and in others for greater resistance to scrubbing.

8-10. *Color pigments.* Color pigments can be obtained from deposits in the earth's crust or through chemical processes.

8-11. Earth colors. The most widely known earthy colors in the painting industry are: yellow ocher, raw and burnt sienna, and raw and burnt umber.

8-12. Yellow ocher contains hydrated oxide of iron as a coloring matter. Various ochers contain 10 to 60 percent hydrated oxide, the remainder being silicous matter or clay. In color, yellow ochers vary from pale to very dark yellow, almost olive. When of good quality they are excellent pigments, permanent in color, and combine well with all paint vehicles as well as other pigments. With white pigments, they produce fine cream or buff tints. They are used primarily as tinting colors.

8-13. Raw sienna resembles yellow ocher in general composition, since it is colored by hydrated iron oxide. It is brownish yellow in color. When used with white, it produces cream tints which have greater color strengths than ochers. Raw siennas are valuable as staining and graining colors. They are undesirable for body colors.

8-14. Burnt sienna is obtained by roasting raw sienna, thereby producing a strong reddish brown pigment. Burnt siennas are used to a lesser degree than the raw sienna. However, they are very valuable pigments when used for shading and glazing.

8-15. Raw umber is similar in composition to the siennas. It has a greenish brown color, is permanent, possesses medium opacity, and mixes well with paint vehicles. Raw umber gives drab tints with white, and a great variety of other shades when mixed with color pigments, for which purpose it is extensively used.

8-16. Burnt umber is calcined raw umber. It possesses a rich brown color which, while darker than raw umber, is free from redness. Burnt umber is used in practically all types of paints and stains.

8-17. Chemical colors. Chemical colors are very important today and are used more than earth colors because they can be produced cheaper by chemical reaction from basic raw materials. These colors consist of blue, green, maroon, orange, red, yellow, brown, and violet pigments.

8-18. *Metallic pigments.* Metallic pigments are used to form a metallic film in paints. The most common are aluminum, copper, bronze, and zinc.

8-19. Aluminum pigment. Aluminum pigment is largely pure metallic aluminum and contains appreciable amounts of polishing lubricant, a mixture of stearic and other fatty acids. It may be purchased in either paste or powder form. An average mixing formula for the production of aluminum paint is 2 pounds of aluminum powder or paste to 1 gallon of mixing varnish.

8-20. Copper pigments. Copper bronze powders are usually alloys of copper with small amounts of zinc and iron. Approximately 1 to 2 pounds of metal per gallon will give good hiding qualities. Copper bronze in combination with small amounts of a toxic substance, such as a mercury or arsenic compound, is used for making anti-fouling ship bottom paint. Various shades from a light brass to a dark antique copper are used in nitrocellulose lacquer to make the popular brass and bronze finishes.

8-21. Zinc pigment. Zinc dust is a metallic grey powder with about 3 percent zinc oxide on the surface. This is a recent development and has gained importance as a pigment for making metal protective coatings.

8-22. *Black pigments.* One of the most important black pigments known to the paint industry is lamp black. It is most commonly used for shading paints, since it has exceptionally great shading strength and is extremely permanent.

8-23. *Extender pigments.* Extender pigments are certain white or colorless natural substances which are ground into a fine powder and added to paints:

- To provide a solid base for color pigments.
- To make the paint film porous so that a normal amount of moisture may pass through it without pushing off the paint film.
- To reduce the excessive spreading rate of paints, thereby increasing the thickness of a paint film.

8-24. Some of the more important extender pigments are:

Barytes (barium sulphate).
China clay (aluminum silicate).
Mica.
Silica (glass sand).
Talc (magnesium silicate).
Whiting (calcium carbonate).

8-25. **Vehicles.** In a layman's language, the vehicle is defined as the liquid portion of a paint, enamel, lacquer, or similar substance which holds the pigment in the solution. The vehicle may be

any of such liquids as drying oils, volatiles (thinners, solvents), driers, resins, and varnishes. It is perhaps the most important part of the coating, as it furnishes the desired qualities of adhesion, toughness, flexibility, and resistance to various environments. It gives the paint its strength and life. The vehicle is usually divided into two parts: the nonvolatile (solid) portion consisting of oils, resins, or plasticizers; and the volatile (liquid that evaporates) portion consisting of solvents, diluents, and driers. When the volatile portion evaporates, the nonvolatiles form the actual film on the surface.

8-26. *Drying oils.* An oil is classified as a drying oil if it will set or harden under normal exposure conditions when applied as a thin film. Some of the most commonly used drying oils are linseed oil, soybean oil, tung oil, oiticica, perilla oil, fish oil, and castor oil.

8-27. Linseed oil, the most important of drying oils and the principal nonvolatile paint vehicle, is obtained from flaxseed. It is used as the basic vehicle in paint because it has a natural ability to dry in the open air, forming an elastic, durable solid film which resists the attack of weather and wear.

8-28. Soybean oil, a slower drying oil than linseed oil, is generally used with faster drying oils. Its main use is in varnish vehicles for interior paints and enamels; paints made with soybean oil resist yellowing. It is used in some of the best interior white enamels

8-29. Tung oil is one of the chief oils used in the manufacture of fast drying, waterproof oil varnish. Since raw tung oil dries rapidly but not to a smooth film, it is not used as such in exterior house paints; whereas linseed oil is almost universally used. Its chief usage is in the manufacture of varnishes.

8-30. Oiticica oil is extracted from the seeds of certain trees growing in northern Brazil. It is used in the manufacture of paints and varnishes. It is similar to tung oil.

8-31. Perilla oil is extracted from the seeds of the perilla plant grown in Manchuria. It is extensively used in the manufacture of varnish because of its superior drying and film-forming qualities.

8-32. Fish oil is mostly extracted from the menhaden and pilchard; it is satisfactorily used for covering hot surfaces such as smoke stacks where hard drying paints are not suitable.

8-33. Castor oil is produced from the castor-oil plant. Its use has increased industrially since being accepted as a satisfactory replacement for tung oil.

8-34. *Volatiles (thinners, solvents).* Volatiles, more commonly called thinners, are organic liquids used to reduce the viscosity of a vehicle or paint to a suitable brushing or spraying consistency. Volatiles control many other properties of the paint, such as ability to penetrate and/or wet the surface being coated, leveling, lap time, dispersion of pigments, and ease of brushing or spraying. Some of the more common volatiles are: turpentine, mineral spirits, naphtha, xylene, acetone, and various alcohols, ethers, ketones, and esters. Water, of course, is used as thinner for water emulsion paints. In the selection of volatiles to reduce a paint in the field, directions of the paint manufacturer or of the specifications should be followed, since some paint vehicles will not mix with certain volatiles.

8-35. *Driers.* A drier is a catalytic agent which, when added to a drying oil or a paint or varnish containing oil, hastens hardening of the film. The most common driers used in paints are oil-soluble naphtenates of cobalt, manganese, and lead. Lead driers promote hard drying throughout the thickness of the film and influence the rate of polymerization of the vehicle more than they do the rate of oxidation. Lead driers are not as strongly catalytic as others in promoting drying of paint films. Cobalt driers assist oxidation strongly and, if used alone, may cause wrinkling because of rapid drying of the outer layer of the film (see fig. 34).

8-36. A given paint or vehicle may make use of one, two, or all of the three drier types, depending on the nature of the paint product. Too much drier or improper combination of driers may adversely affect the durability of the film, or it may not allow the paint film to harden. Finished paint products should be purchased with driers added whenever practicable, since the addition of driers in the field is readily susceptible to error.

8-37. *Resins.* Natural and synthetic resins available to the paint industry are so numerous and varied in properties that they will only be mentioned. This same complexity and multiplicity make a definition almost impossible. Resins

Drier	Characteristic	If Used Alone
Lead	Hard Drying Throughout	Tough Film
Manganese	Intermediate Drying	Brittle Film
Cobalt	Rapid Drying Outer Layer	Wrinkling of Film

Figure 34. Characteristics of driers.

together with drying oils comprise the bulk of film forming materials, or binders in the surface coating field. Natural resins, such as resin and shellac, are, in general, exudations from trees and insects. Synthetic resins, such as alkyds, acrylics, vinyls, phenolic, silicones, epoxies, and polyurethanes, are manufactured from basic organic material, such as petroleum, alcohol, coal tar, and vegetable oils.

8-38. Alkyds are the backbone of modern paints in a great many combinations. The alkyds, characterized by toughness, flexibility, and durability, are used in exterior and interior coatings for utility and decorative purposes. They do not have good chemical resistance.

8-39. The acrylics have outstanding light resistance and outdoor weather durability, with moderate chemical resistance. Used with nitrocellulose as a hardener, they have better drying properties and increased hardness.

8-40. Vinyls are used where construction materials, metal and wood, must be protected from high humidity or acid caustic environment.

8-41. Phenolics appear in varnishes and enamels requiring extra hardness and abrasion resistance.

8-42. Silicones appear primarily in heat-resistant coatings. They are not particularly hard surfaced and may craze. They are usually baked.

8-43. Epoxies have outstanding adhesion and chemical resistance. In combination with other resins, they appear as baking enamels. Air-drying types are reacted with converting agents just prior to application to set up films of improved characteristics.

8-44. Polyurethanes are also converted or catalyzed in coating applications. The polyurethane coating is characterized by a very high gloss, superior toughness and outdoor durability, and good chemical resistance.

8-45. *Varnishes.* Varnishes contain oil, resins, thinners, and driers. Drying oils and resins are combined in definite proportions. Thinners and driers are then added. The various types of resins, oils, and other available components make it possible to produce varnishes adaptable to many uses. Varnishes may be used as such for clear coatings or as vehicles for pigmented paints.

9. Types of Protective Coatings

9-1. What is the best type of protective coating to use? There is a demand by those responsible for the selection of paint for recommendations as to the "best" paint for every class of surface. There are many factors, such as the condition of the surface, the method of application, curing conditions, service expected by the user, and the cost against the length of time the appearance must remain satisfactory, that must be considered.

9-2. The materials mentioned in the preceding section are used to make many different types of organic finishes for decorative and protective purposes; however, some of the most common types are the oil base paints, enamels, lacquers, water-mixed paints, varnish, shellac, and stains.

9-3. **Oil-Base Paints.** These paints consist principally of a drying oil (usually linseed) mixed with one or more pigments. Oil paints may be modified by addition of varnishes. Exterior surfaces of houses and metal surfaces in atmospheric exposure are usually coated with paints of the oil type. The vehicle in these paints can be a combination of raw and processed oils or it may be a single oil, depending on the properties desired in the paint. The pigments and quantities used in oil paints are usually selected on the basis of cost and their ability to impart to the paint the properties desired, such as durability, economy, brushability, and color. Oil-base paints are characterized by easy application, slow drying, and good ability to wet the surface being coated. They normally chalk in such a manner as to permit recoating without costly surface preparation.

9-4. **Enamels.** Enamel is commonly thought of as a pigmented, varnish vehicle paint which has good flow and leveling properties and dries fairly rapidly (4 to 16 hours) at normal temperature. In general, the ability of enamel paints to wet the surface and coat surface irregularities is not as good as oil paints, and they generally fail by chipping, cracking, blistering, or similar action resulting from gradual decrease of elasticity with age. Enamel films are generally harder, tougher, and more resistant to abrasion and moisture penetration than oil-type paints. They can be applied by brushing, spraying, or dipping. When the application is by brush, flow the paint on the surface rather than brushing it out as with oil paints. Enamels of the baking type are widely used in industrial finishing.

9-5. **Lacquers.** Lacquers differ from oil paints and enamels in that they contain some type of resin as a vehicle. Lacquers are normally applied by spray since most types dry too fast for brushing. Lacquers are usually applied by a series of thin films. A hard, brittle coating, a tough and elastic coating, a high or low gloss film, and many other variations can be obtained by proper choice of lacquer materials. Durability of lacquer finishes on some makes of auto-

mobiles is proof that good protection is given by lacquers. The new vinyl paints which are technically lacquers have outstanding durability in many types of exposures.

9-6. **Water-Mixed Paints.** These paints are distinctly different from other paints in that the vehicle is an emulsion of binder and water. Water paints have the advantages of easy application, drying by evaporation of water, easy reduction of viscosity with water, and easy cleaning of tools used for application with soap and water. This type of paint was originally used as interior coating but recent usage has broadened to the use of water paint to outside surfaces. Water paints fall into many categories, but casein, latex, and calcimine are the more important.

9-7. *Casein.* In casein paint, casein (protein of milk) is used as the binder. Casein paint consists of powdered casein, hydrated lime, inert and hiding powder pigments, preservative, and tinting colors. Small amounts of vegetable oils are added to improve washability. The principal pigment added to casein paint is titanium.

9-8. Casein paints usually cover a surface wall in one coat, dry rapidly, and adhere to new plaster without scaling or blister.

9-9. Casein paints are designed for interior decorative work on plaster, wallboard, fibreboard, stucco, cement blocks, etc. Casein paints are also available for exterior masonry, stucco, brick, and concrete.

9-10. *Latex (emulsions).* This term was originally used to describe raw latex rubber emulsion paint (rubber in water). Now the term is used in connection with all resin and rubber emulsion paints. These paints thin with water, and the brushes are cleaned with water. Many types have been made, but vinyl and acrylic emulsions are the most popular.

9-11. Emulsion paints are very good on interior and exterior masonry because they breathe, allowing vapor to slowly pass through the film. Emulsion paints are glossless, and special colors must be ground in a suitable vehicle to color them.

9-12. *Calcimine.* This paint is a mixture of powdered pigments, such as whiting and china clay, and glue. The paint is compounded by mixing the prepared pigments with water. The paint is an inexpensive way of covering wet and dry wall interior surface. A glue and water size may be used on wet walls. The best results, however, are obtained by using a varnish sealer and primer before the calcimine is put on.

9-13. **Varnish.** A varnish is usually a transparent liquid, though occasionally opaque, which, when spread in a thin film over a surface for protection and decoration, will dry to a hard and transparent coating. The kinds and types of varnishes are numerous. Some manufacturer's catalogues list from 100 to 200 varieties. Oil varnishes are the most important and include spar varnish, interior varnish, flat varnish, rubbing varnish, and color varnish. All of the above varnishes are extensively used to finish and refinish interior and exterior wood surfaces, such as floors, furniture, woodwork, metal fixtures, etc. They produce a durable, elastic and tough surface which dries to a high gloss finish and does not mar easily. Exterior varnishes are specially formulated to resist weathering.

9-14. **Shellac.** Shellac comes from the secretions of the lacca insect. This insect secretes a resinous material on trees which is gathered,

	BURNT SIENNA	VANDYKE BROWN	ROSE	RAW SIENNA	RAW UMBER	BURNT UMBER	DROP BLACK
CHERRY	1 1/2 Pint						
MAHOGANY		1 Part	1/2 Part				
LIGHT OAK				1 Part	1/4 Part		
DARK OAK	Touch			1 Part		1/2 Part	
OLD MAPLE	1/2 Part			1/2 Part	1/2 Part		
WALNUT		1 1/2 Part					1/4 Part
WALNUT	1 Part						1/4 Part

Figure 35. Mixing oil stains.

washed, and ground, and then melted and placed on a thin sheet. These thin sheets of shellac are then broken into flakes—one of the forms in which shellac is sold on the market. Shellac is now produced by chemicals in modern factories. Shellac is soluble in alcohol and is used extensively as a finishing material, especially on furniture as an undercoat and over knots to prevent "bleeding."

9-15. **Stains.** Stains are used to change the color of various types of wood and to bring out the beauty of the grain. They are usually applied before the varnish or other finish; however, some oil stains are used as a preservative for shingles and other rough exterior wood surfaces. The most commonly used stains are the water, spirit, oil, and varnish.

9-16. *Water stain.* Water stain is cheap, penetrates the wood deeply, and is transparent. It produces an even penetration and gives the most even and clearest tone of all stains. A disadvantage in its use is that the water raises the grain of the wood which is being finished, requiring extra sanding. Water stains are used for inside woodwork and furniture.

9-17. *Spirit stain.* Spirit stains are made by mixing aniline colors in alcohol. They are quick in drying and the colors are brilliant, transparent, and beautiful. By using a spirit stain, a surface may be stained, filled and shellacked, or varnished the same day. For this reason, these stains are useful for repair and touchup work on floors, woodwork, and furniture and for all sorts of quick jobs. Spirit stains have the characteristic of penetrating old varnish surfaces to a greater depth than other stains, but they are not permanent in sunlight or very strong light.

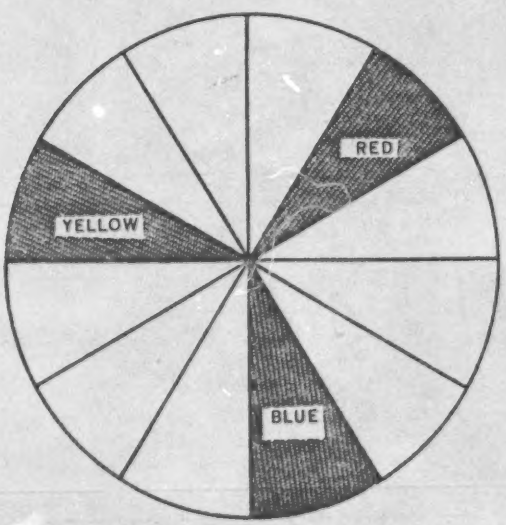

Figure 36. Primary colors.

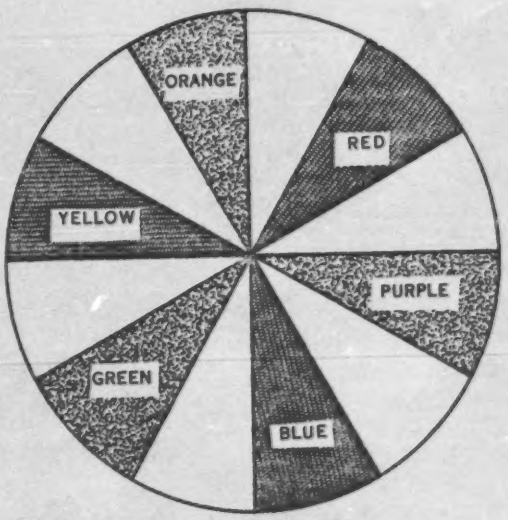

Figure 37. Secondary colors.

9-18. *Oil stains.* Oil stains are probably the most convenient to use in finishing woodwork of various kinds, since they are easily obtained, easily applied, and do not raise the grain of the wood. They dry slowly enough to permit brushing and rebrushing without showing lap marks. Whenever the color is too dark, after the stain is applied, some of it may be wiped off to produce a lighter color. In the hands of an unskilled workman, the results obtained will be better than by using other types of stains. Oil stains are mixed to a base of ½ gallon boiled linseed oil and ½ gallon of turpentine or mineral spirits as shown in figure 35.

9-19. *Varnish stain.* Varnish stain is composed of a varnish to which a stain has been added. When you use a varnish stain, it is possible to stain and varnish in one operation.

9-20. Now that you have a basic knowledge of the types of protective coatings, you are about to undertake the most important task of the trade—mixing and preparing the protective coatings.

10. Mixing and Preparing Protective Coatings

10-1. How can I mix the correct color? Coloring and tinting paint is not difficult when a new mixture of paint is first made; however, matching paint already applied on a surface is difficult, because paint changes shades after drying and aging.

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10-2. Coloring and tinting paint for most painters is a matter of trial and error. To be a professional protective coating specialist, it is necessary that you understand the color combinations, color mixing, tinting, color harmony, how to mix paint by boxing and by using power equipment, how to thin paint, and the special procedures required for mixing aluminum paint.

10-3. **Color Combination.** Skillful mixing of colors is one of the most important aspects of painting and decorating, especially in interior decorating. There are three primary colors of paint—blue, red, and yellow (see fig. 36).

10-4. Secondary colors are made by mixing any two of the primary colors together. For instance, yellow and red form orange; red and blue form purple; and blue and yellow form green (see fig. 37).

10-5. The remaining six places on the color wheel are filled by combining adjacent primary colors and secondary colors. These are called tertiary colors. This fills the color wheel with 12 colors, all full strength, which are known as hues. (See fig. 38.) From these hues, you can attain tints, tones, and shades.

10-6. Tints are lighter than hues. They are formed by adding white to the color on the color wheel. Shades are darker than hues and are formed by adding black to any of the colors. Tones are made by adding both black and white to the colors on the color wheel.

10-7. **Color Mixing (Oil Paint).** When mixing oil paint on the job, colors in oil are easier to mix into the paint vehicle than powders. Colors in oil consist of dry pigments (powders) ground in a vehicle of approximately 80 percent linseed oil and 20 percent volatile solvent which will make the paste of a consistency that will satisfactorily flow from the containers. The major colors in oil are the blacks, blues, browns, greens, oranges, reds, and yellows.

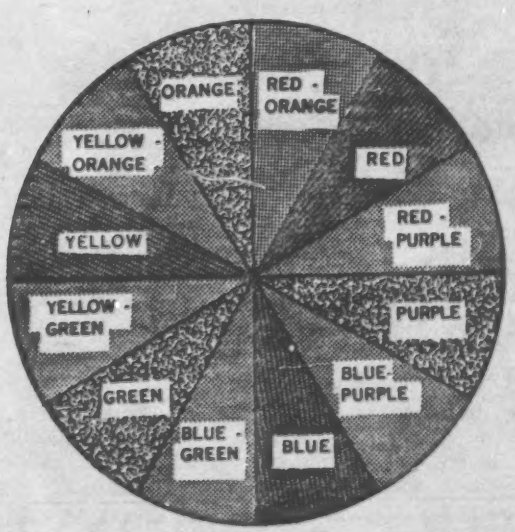

Figure 38. Hues.

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10-8. *Blacks.* The blacks used for shading and for solid colors include pigments such as boneblack, high-colored carbon black, carbon black, lamp black, and synthetic black iron oxide. Carbon black and lampblack are the strongest in shading strength. Carbon black and boneblack are blacker in color. Lampblack, however, is the one most frequently used. Black iron oxide is used as a pigment in black metal protective paints, and is also used for shading purposes. The pastes can be thinned to brushing consistency by adding three parts linseed oil, one part spar varnish, and one-half part drier to one part of the pigment paste.

10-9. *Blues.* The blue pigments are iron blue (Prussian blue), ultramarine blue, and copper-phthalocyanine blue. The permanency of iron blue is affected by alkalies, while ultramarine blue is susceptible to acids. Copper-phthalocyanine blue is more durable in the light blue tints. These pigments have a fair permanency in tints or solid colors exposed to the weather.

10-10. *Browns.* Brown pigments include metallic brown, burnt sienna, burnt umber, raw umber, and synthetic brown iron oxide. The browns are among the most durable pigments used in paints exposed to the weather. Although adaptable as a trim color, metallic brown is more often used as a solid color. It is used to a great extent in paint for barns, metal roofs, and freight cars. The other browns are often used for tinting paints and making stains. Brown iron oxide is also used as a pigment in some paints and enamels.

10-11. *Greens.* The green pigments are chrome green and chromium-oxide green. Chrome green, composed of chrome yellow and iron blue, is used to make tints or solid color paints, which, by the way, are sensitive to alkalies. Chromium-oxide green, more permanent of the two, is used with white for tinting purposes. It does not have the tinting strength of chrome green, but withstands high temperatures and is not effected by alkalies or acids.

10-12. *Oranges.* Orange pigments consist of two shades of chrome orange that are used for tinting and making solid color paints. The pigments are basic lead chromate that is processed as light and dark. The dark pigment is used in making international orange paint. Both light and dark pigments are relatively permanent when exposed to the weather.

10-13. *Reds.* The reds include pigments such as Venetian red, bright red iron oxide, Indian red, toluidine red, and mineral red. All of these pigments are used for tinting purposes, except toluidine red. Indian red and bright red iron oxide are very permanent and are used extensively in all types of paints, enamels, and stains. Venetian red and mineral red are often used in barn and roof paints. Toluidine red, which is a bright red, is permanent when exposed to the weather.

10-14. *Yellows.* The yellows include a number of pigments. They are: lemon chrome yellow, medium chrome yellow, yellow ocher, primrose chrome yellow, yellow iron oxide, raw sienna, and zinc yellow. The chrome yellows are satisfactory for tinting exterior paints. Yellow-ivory colored paste is made by adding and mixing 1 pound of medium chrome yellow to 50 pounds of white lead paste. Yellow ocher mixed at a ratio of 1 pound to 50 pounds of white lead paste makes a durable chamois colored paste for exterior paint.

10-15. Raw sienna is used more for tints and stains than for solid color or trim paints. When mixed with white lead in different amounts, it makes durable ivory and buff tints. The yellow oxides are used particularly in solid color paints and for tinting floor enamels. Zinc yellow is used mainly as a rust-inhibitive pigment in metal primers.

10-16. **Color Mixing (Water-Base).** When you are mixing water-base paint on the job, mix color pigments that are soluble in water into the paint vehicle. COLORS IN OIL CANNOT BE MIXED WITH WATER-BASE PAINTS.

10-17. **Tinting or Shading.** When you tint or shade paint with paste, mix the paste with a small amount of the paint vehicle to thoroughly break it up; then, strain through a cheesecloth. When you mix paint to match a certain color, add the tint or shade in small amounts, and test the paint by brushing it on a surface similar to the one to be painted. Allow the paint to dry in order to check for the proper match.

10-18. If the desired match has not been produced, add either more color or more base paint. If you notice streaks of color when you brush out the paint, it is a sign that you have not thoroughly mixed the color into the base paint. If you add too much color to your base paint, you will have to add considerably more base paint to lighten the color. As a result, you will have more paint than you need for the job.

10-19. **Color Harmony.** Below is a list of some Do's and Don't to consider when you select colors.

- DO use light colors in a small room to create an impression of larger size.
- DO have continuing color flow through the building—from room to room—using harmonious colors in adjoining areas.
- DO paint ceilings of a room in a deeper color than walls, if you want it to appear lower—and in a lighter shade for the opposite effect.

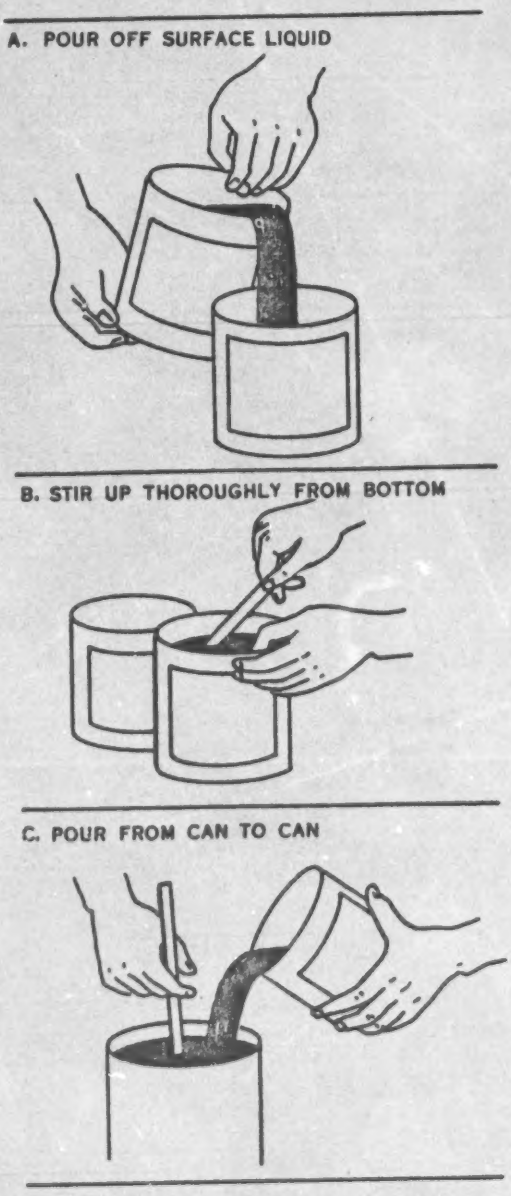


Figure 39. How to box paint.

66

- DO study color swatches in both daylight and nightlight, because colors often change under artificial lighting.
- DO emphasize horizontal lines in a room that is too tall, and emphasize vertical lines in a room with a low ceiling.
- DON'T use a bright color in a large area, or the walls will detract from otherwise decorative furnishings and accent pieces.
- DON'T paint the woodwork and trim of a small room in a color that is different from the background color, or the room will appear cluttered and even smaller.
- DON'T paint unfortunate architectural features—such as radiators, pipes, and similar projections—in a color which contrasts with walls, or they will be emphasized.
- DON'T choose neutral, negative, or "non-colors," just because they are safe, or you may forfeit attractive decorating.
- DON'T use glossy paints on walls or ceilings of living areas since such a surface creates glare.

10-20. **Mixing Paints.** Primers and paints must be mixed (stirred) thoroughly. This will insure that the paint pigment, which usually settles to the bottom of the container, and the paint vehicle will be thoroughly mixed together. Primers and paint may be mixed by boxing or with power equipment.

10-21. *Boxing.* Whenever paint is to be mixed by hand, follow the procedures listed below:

(1) Pry open the paint container.

(2) Pour most of the paint vehicle into a clean and empty container, as shown in figure 39, step A.

(3) Stir the paint pigment which has settled to the bottom of the container into the remaining paint vehicle, as shown in figure 39, step B.

(4) While stirring, gradually pour the paint into the paint vehicle originally poured off.

(5) Stir vigorously and pour the paint from can to can, as shown in figure 39, step C.

10-22. *Power equipment.* Normally, power equipment used for stirring paints is either the shaker or the propeller type.

10-23. Shaker-type mixers are used to stir any type of primers or paint, but preferably those containing highly volatile thinners. These mixers handle from as little as ½ pint to as much as a 5-gallon can, depending upon the size of the machine. A typical machine of this type is illustrated in figure 40. These machines, which are generally electrically operated, blend paint materials by shaking them. The electric motor must be explosion-proof.

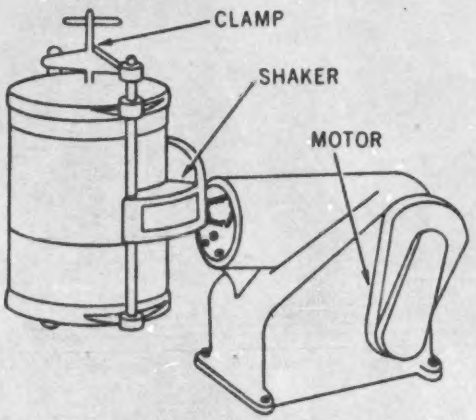


Figure 40. Shaker-type mixer.

10-24. The propeller-type paint mixer, shown in figure 41, is used to stir large quantities of primer and paint in open containers. Paint is agitated by the propellers or paddles attached to an electrically rotated shaft. The electric motor of this mixer also must be explosion-proof.

10-25. **Thinning.** Thinners and solvents have definite functions in the mixing of coating materials, but for economic reasons, packaged products generally contain the smallest percentage possible of volatile material compared to solid. The resulting high consistency makes it necessary to thin package materials to varying degrees to suit the particular material, the application method, and the surface being coated. Always add thinner to the coating material. Adding coating material to thinner may result in an irreversible separation of some of the coating ingredients. It should be added slowly with continual stirring to obtain complete mixing. For all thinning, use only thinners recommended in the instructions on the paint can label. The wrong thinner may destroy certain characteristics of a coating material without immediately giving visual evidence in the wet state. Reduced material which has increased in viscosity due to evaporation will require corrective additions. However, some coating materials which undergo chemical processes, such as polymerization, to create a film cannot be thinned beyond a certain point and remain usable, neither can they be brought back to the correct viscosity by thinning after the chemical action has progressed beyond a recommended point.

10-26. Thinning for the particular job must be determined by good judgment and actual test. Both excessive thinning and too little thinning are detrimental to the normal flow-out characteristics of a coating. It leads to runs and sags

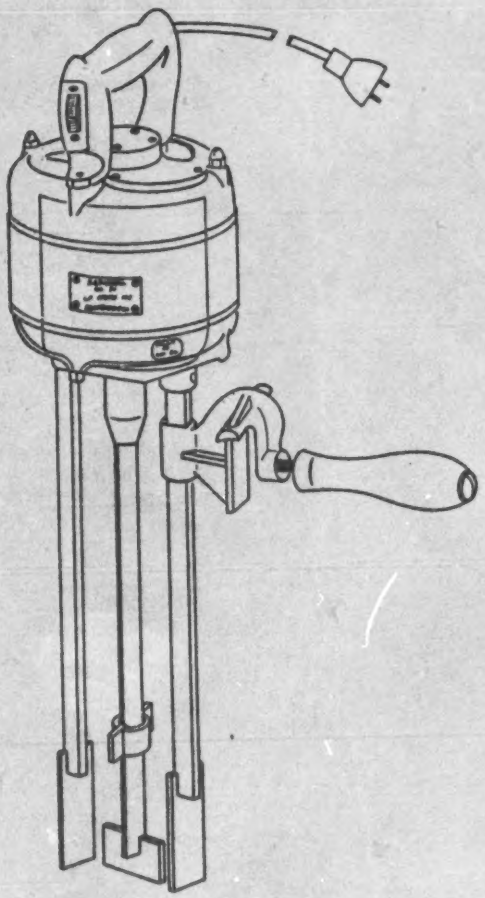


Figure 41. Propeller-type mixer.

on one hand and rough coatings on the other. The amount of thinning for spray application also directly influences the evaporation rate of the volatiles on their passage from the gun to the work (a major portion of the thinner can be lost enroute). The cooling effect of this evaporation, plus the cooling due to expansion of the atomizing air, may lower the temperature of the coating material as much as 20° Fahrenheit below that of the surrounding air. The temperature of the deposited film may fall below the atmospheric dewpoint, and atmospheric water vapor will condense on it. (As an example, when air temperature is 70° Fahrenheit and the relative humidity is 70 percent, the dewpoint is 63° Fahrenheit or, 7° below the ambient temperature.) At this point, the adhesion qualities of enamels may be reduced. The refrigerating effect will also affect drying and the flow-out of quick-drying materials.

10-27. **Mixing Aluminum Pigment.** To overcome the special difficulties which may arise in dispersing aluminum paste or powder pigments in the desired vehicles (lacquers and varnishes), follow these steps closely:

(1) Weigh and measure the amounts recommended on the container.

(2) Place the weighed pigment in a clean container large enough to contain the whole mix and allow room for stirring. In a separate clean container, measure the volume of vehicle to go with the pigment.

(3) Pour the vehicle over the pigment in small quantities. (Never add the pigment to the vehicle.) It is important that the vehicle be added in small amounts and that each quantity is thoroughly stirred before more vehicle is added. Use 10 percent in the first addition, the same in the second, twice as much in the third, and then the remainder. Stir thoroughly to insure complete wetting of the pigment.

(4) Box by pouring from one container to the other several times.

(5) Strain the material through double or triple thickness cheesecloth to be certain no lumps remain.

10-28. During application the aluminum finishing material should be stirred occasionally, but this stirring should be moderate and only enough to keep the pigment in suspension. Too much agitation may cause darkening and loss of leafing power. Since prolonged storage of mixed aluminized coating materials also may destroy leafing power, carefully estimate the quantity of material required for the job or the day's work. If, for unavoidable reasons, the quantity prepared is not used entirely, it may be safely mixed with fresh material in amounts up to 10 percent.

11. Surface Preparation Materials

11-1. How can I do a professional job of painting? Good surface preparation is one key to this question. Different surfaces such as a nail hole in wood trim or the cracks in a plaster wall require different treatment and materials. The different materials available to improve the surface before paintings, such as undercoats, sealers, primers, sizes, wood filler, plastic wood, caulking compound, putty, texture paint, spackling compound, joint cement, and paint and varnish remover, are covered in this section.

11-2. **Undercoats.** Undercoats are the coatings which are applied prior to the finishing, or final, coat. On old work, the undercoat is the first coat applied; on new work, the undercoats are the coats applied after the primer and before the

final enamel. Undercoats are essential for their hiding power and for providing a smooth surface for the finish coat.

11-3. **Sealer.** A sealer is a coating used to fill the pores of absorbent surfaces in preparation for painting. By preventing the absorption of oil from a paint, sealers not only reduce the number of coats of paint required but also insure a stronger film. Some sealers are used to protect the finish coat from attack by chemicals that are present in the surface to be coated. Clear or pigmented sealers are usually applied as the first coat to surfaces.

11-4. There are many commercial sealers; one type can be easily made of a mixture of shellac and alcohol. Reduce the shellac with alcohol 4 to 1 if it is to be used over a filler, and 7 to 1 if it is to be used over stain. Then pour the mixture into an equal amount of lacquer to make the sealer.

11-5. **Primers.** A primer is a film-forming material used as a first coat of paint, which provides adhesion for the following coats and prevents undesirable chemical reaction to a surface. It may be a thinned first coat of paint or a specially prepared product. Different types of primers are available for different types of surfaces. Included here are exterior wood primer, epoxy primers, phenolic resin primer-sealer, wash primer, zinc chromate, and red lead base primer.

11-6. *Exterior wood primer.* Wood primers are usually a thinned coat of the paint to be used or a specially prepared coat. Specially prepared coats consisting of 35 to 40 percent white lead, 10 to 15 percent titanium, and the balance extenders make a very good wood primer.

11-7. *Epoxy primer.* Epoxy primer is a two-component pigment primer specially made to stick well and reflect heat. It is nonchalking, nongloss, and very resistant to chemicals, lubricants, and corrosive atmospheres.

11-8. This primer is made primarily for spraying; however, it may be brushed on small areas. Mix it by adding equal parts by volume of the pigmented primer with the catalyst just before using. Use within 10 hours after mixing.

11-9. Because it is an epoxy, this primer is difficult to remove. There are several types of epoxy primers used on different items. For this reason, you should follow the manufacturer's recommendations when using them.

11-10. *Phenolic-resin primer-sealer.* A new type of finish well suited for open grain woods is a phenolic-resin primer-sealer which penetrates into the pores of the wood, dries, and equalizes the density of the hard and soft grains. Staining and painting of wood thus treated eliminates alternating light and dark streaks that are frequently present on untreated wood. This sealer is light amber in color and almost as thin as water. Pigments can be added as well as colors in oil to produce almost any color desired.

11-11. *Wash primer.* The term "wash primer" designates a specific material which combines the properties of an inhibitive wash coat or metal conditioner with the properties of the conventional anticorrosive primer. The essential components of wash primers are phosphoric acid, chromate pigment, and polyvinyl butyral resin. Wash primers can be formulated that are equally effective over iron, steel, aluminum, treated magnesium, copper, zinc, and a wide variety of other metals. The advantages of wash primers used by the military are listed below:

- Easily applied and dry rapidly.
- Usable over wide ranges of temperatures and humidity.
- Can be applied to a variety of metals with good results.
- Provide temporary protection until protective coating is applied.
- Prevent or retard under-film corrosion.
- Exhibit high degree of adhesion to metals.
- Upgrade performance of subsequent protective coatings.

11-12. *Zinc chromate primer.* Zinc chromate primer is used in tremendous quantities by the armed forces. The rust inhibitive qualities of zinc chromate prove very satisfactory. It is not used in a straight linseed oil vehicle but is used in synthetic resin vehicles of the phenolic resin or alkyd resin types. For priming structural steel, the addition of some raw linseed oil is advantageous. Zinc chromate primer is generally used as a primer for metal surfaces, such as structural steel, bridges, tanks, refrigerators, railroad cars, motor vehicles, aircraft, etc.

11-13. *Red lead base primer.* There are four types of red lead base, ready-mixed paint, types I, II, III, and IV. These four types of paint can be applied by brush, spraying (hot or cold) or dipping after thinning with mineral spirits.

11-14. Type I is a red lead and linseed oil paint used on bridges, similar structural steel, and other metal surfaces. You can use this type, but you must allow 36 hours before applying another coat. The linseed oil in this paint serves to wet the surface despite the presence of small amounts of corrosion products impractical to remove.

11-15. Type II is a red lead, linseed oil, and alkyd varnish used in place of type I when recoating is necessary within 16 hours.

11-16. Type III is a red lead-alkyd varnish paint used for painting thoroughly clean iron

and steel surfaces and for touchup work where drying in a 6-hour period is desired. This type does not have the surface wetting properties which characterize paints containing linseed oil, and, consequently, must be applied to exceptionally clean surfaces. Because structural steel (bridges, tanks, etc.) is rarely cleaned free of all corrosion products, this type is not generally intended for such use.

11-17. Type IV is a red lead-phenolic varnish paint used as a primer on iron and steel subjected to severe humid conditions or fresh water immersion. In addition to its excellent water impermeability, the paint film exhibits good resistance to acid and alkaline environments and can be used on water storage tanks, structural work on dams, structural metal and equipment in bottling plants, laundries, etc. Apply the paint only to exceptionally clean surfaces, because this type does not contain linseed oil or other wetting agents.

11-18. **Sizes.** Size is used to fill the pores of plaster or wallboard so that paint will stay on the surface. There are several types of size available, but the main types are glue-water and a thinned varnish. Varnish size is prepared by thinning 1 gallon of varnish with 1 quart of turpentine. Mix glue and water until the mixture will spread easily. Primers and sealers have been improved to the extent that sizing is seldom needed for paint preparation today.

11-19. **Wood Filler.** The purpose of wood filler is to provide a smooth, even finish on wood having open grain, such as walnut, mahogany, and oak. Paste wood fillers are usually made of silex or silica ground in linseed oil and Japan drier with various pigments added for color. Fillers come in standard colors such as mahogany, light oak, dark oak, maple, walnut, black, white, and natural.

11-20. Most fillers come in paste form and are too thick to use without thinning. Thin by adding turpenting, naphtha, or special thinner according to instructions on the container. About ½ pint of thinner to 1 pound of filler is required for coarse, open-grained woods. Closer grained woods, such as walnut, rosewood, mahogany, and zebra-wood, require a mixture of about 10 ounces of thinner to 1 pound of filler. In mixing filler, it is well to add a little thinner at a time and then by trying it you can get the desired consistency.

11-21. **Plastic Wood.** Plastic wood is a product used to fill holes in wood, especially if the finish is to be clear. Plastic wood is available commercially and can be purchased in various size cans and tubes. This filler dries very rapidly and it must be kept in airtight containers.

11-22. **Caulking Compound.** Caulking compound, which usually contains asbestos fiber, a pigment for opacity, fish oil or soybean oil, and a drier, is used to seal joints around doors and windows and between the baseboard and wallboard. It is a compound that will remain elastic for some time. This allows it to expand and contract with the movement of the building. There are two main types of caulking compound: the gun type, which is forced into cracks and crevices in ribbonlike form, and the knife type, which is applied with a putty knife. It can also be used as window sash putty. It is also available in rolls or strips to be applied by pressing it into the joint.

11-23. **Putty.** Putty is used to fill holes in surfaces and to replace checked or broken putty around windows. Commercial putty is made of white lead and whiting combined with linseed oil and a neutral oil to prevent it from drying too rapidly. Sometimes plastic wood is substituted for putty when filling holes in wood.

11-24. **Texture Paints.** Texture paints are of heavy consistency designed to be used to produce a textured effect on a surface. Since they are thick and can be molded to obtain various decorative effects, they are particularly suitable for finishing sheetrock in dry wall construction. Texture paint can be made on the job by mixing joint cement with a paint to a butter consistency. Color can be mixed before application.

11-25. **Spackling Compound.** Spackling compound is a white powder. When mixed with water, it sets quickly without swelling or shrinking. It is used to apply a texture effect to smooth interior surfaces such as plaster, sheetrock, wallboard, gypsum-board, and primed and unprimed wood.

11-26. **Joint Cement.** Joint cement is used to fill the depressions left by a hammer when nailing sheetrock (hammer marks). It is also used with perforated tape to fill the recessed edges of sheetrock joints. Joint cement is mixed with water until a thick paste is formed. It is normally applied with a broad blade putty knife or a cement trowel.

11-27. **Paint and Varnish Removers.** Paint and varnish removers are made of chemical solvents which are spread over the old finish to soften it so that it can be removed with a steel scraper, putty knife, or steel wool. It is available in paste or liquid form; the liquid form is faster acting.

11-28. We have covered some of the most frequently used surface preparation materials, however there are so many types on the market today that it would be impractical to list them

all in this chapter. The importance of the selection of the proper surface preparation materials for the protective coating specialist cannot be overemphasized.

12. Selecting Exterior Protective Coatings

12-1. What type of protective coating should I use on this surface? What types of protective coatings are available? The protective coating specialist must consider the type of surface before attempting to select a protective coating for a particular job.

12-2. **Type of Surface.** The type of surface to which the coating is to be applied is the first consideration whether you're dealing with wood, metal, or masonry.

12-3. *Wood surfaces.* When you paint exterior wood surfaces, you must decide whether the two-coat or three-coat system is to be used. Primer is not necessary when you repaint previously painted surfaces that are in good condition. Surfaces that have never been painted should be given a primer coat, body coat (undercoat), and a final (finish) coat.

12-4. Exterior white oil paint (house paint) is most often chosen for the main exterior surfaces of buildings. When the three-coat system is used in painting exterior wooden surfaces with ready-mixed paint, a self-primer can be made by adding approximately 1 pint each of drying oil and turpentine to 1 gallon of final coat exterior white oil paint. When the two-coat system is used, the addition of 1 pint of drying oil to the paint is sufficient.

12-5. When the three-coat system is employed, applicable ready-mixed primers may be used without basically changing the paint.

12-6. *Metal surfaces.* Galvanized iron, tin, or steel building materials are available in various types, all of which may rust if not protected against moisture. Copper building materials, although they will not rust, will give off a corrosive wash which will discolor the metal. Aluminum, like copper, will not rust, but will corrode if not protected. Conventional house paints or exterior enamels can be applied to these surfaces, if the proper prime coating is first applied. Aluminum paint can be used for painting metal surfaces.

12-7. *Masonry surfaces.* Masonry surfaces—brick, cement. stucco, cinder block, or asbestos-cement—can be coated with a variety of paint products. One of the newest ideas in painting brick is a clear coating which withstands weather and yet allows the natural appearance of the surface to show through. Cement-base paints and rubber-base coatings, vinyl and alkyd emulsion paints are also used on many types of masonry. Almost all exterior house paints may be applied to masonry; however, the surface must be prepared properly.

12-8. Good results in painting concrete porches and steps can be obtained with a rubber-base coating, or similar product. Roughening the surface slightly with muriatic acid is recommended before painting concrete that is hard and glossy. Surfaces may also be primed with an alkali-resistant primer.

12-9. **Kinds of Exterior Coatings.** Listed below are several of the more commonly used coatings for exterior surfaces. Note that some can be used on both exterior and interior surfaces. No attempt has been made to list all of the paints available to the protective coating specialist. New paints are being developed each year, and it is a wise protective coating specialist who reads the latest literature and technical publications to keep abreast of these new developments.

12-10. *Exterior white oil paint.* Exterior white oil paint is a glossy paint compounded for use as second, or body, and final coats on outside wood, metal, and masonry surfaces. If you are to be successful with this paint, the primer must be suitable for the particular material. A self-priming paint for wood and masonry can be made from the paint by adding 1 pint of linseed oil to 1 gallon of the paint.

12-11. One type of this paint is composed of several white pigments (multiple pigment), which chalk more or less, depending upon the pigments and the amount of each that is included. The other type is a single-pigment paint that chalks very little. Chalking is a desirable characteristic of paints where the surface will decompose into a fine powder and wash away; thereby, restoring a clean surface.

12-12. One class of multiple-pigment paint (titanium-lead-zinc) is a white paint, for general use, compounded so that it will chalk considerably. Another class of multiple-pigment (titanium-zinc) is a lead-free white paint designed for use where sulfide fumes exist. This paint is not compounded for tinting purposes.

12-13. Still another combination of white pigments (titanium-lead-zinc) similar to the first class of this paint, compounded for tinting purposes, forms a third class of multiple-pigment exterior gloss white oil paint. The single-pigment type of this paint is a white lead glossy oil paint that comes in white or colors.

12-14. When the surfaces of wood, metal, or masonry are to receive three coats of this paint, the mixtures used for body and final coats may be thinned by adding 1 pint of turpentine or mineral spirits to 1 gallon of paint.

12-15. *Exterior Masonry white oil paint.* Exterior masonry paint is intended for exterior body or final coats on primed masonry surfaces, except floors. The paint, white or tints, dries to a flat finish; therefore, when a glossy finish is desired, exterior glossy paints must be used. Because any paint adheres poorly to glazed surfaces, such surfaces must be roughened by acid washing, sandblasting, or rubbing the glaze off with abrasive stones. Old coatings of organic or cement-water paints that are firm need not be removed. However, any of the oil paint that is loose or flaking must be removed to insure adhesion of the new paint.

12-16. A good self-primer for exterior masonry paint can be compounded by mixing ½ gallon of nonreactive spar varnish and ¼ gallon of turpentine or mineral spirits with 1 gallon of exterior masonry paint. Since moisture is detrimental to exterior masonry paint, the surfaces must be thoroughly dry before the primer, body, and final coats are applied.

12-17. *Zinc oxide oil or resin paint.* A zinc dust and zinc oxide paint is manufactured for use as a primer for zinc surfaces. The paint may also be used satisfactorily for body and final coats. There are several types of this zinc primer. One type is an air-drying paint having a linseed oil vehicle. Another type, an enamel, has glyceryl phthalate vehicle, which causes it to dry faster. This enamel can be baked dry if it is so desired. Still another type, also an enamel containing phenolic resin, is especially recommended for priming the inside surfaces of steel water tanks.

12-18. Prior to using zinc primer on new surfaces, the surfaces must be cleaned with turpentine, mineral spirits, or with some approved cleaner to insure good adherence of the primer coat.

12-19. *Exterior chrome green oil paint.* Chrome green oil paint is an exterior paint of average quality to be used on wood, metal, and masonry over a gray tinted body coat. Another type of this paint contains a vehicle of spar varnish; consequently, it is a glossy enamel of greater durability. It is known as trim enamel, and it has good hiding power and color retention.

12-20. *Exterior olive drab oil paint.* Exterior olive drab paint is suitable on wood, metal, and masonry exposed to the elements. It is semigloss paint that has good color retention, and it is used for body and final coats.

12-21. *International orange oil paint.* International orange paint is of three different types and two colors, namely, chrome orange (color of a ripe tomato) and orange red. The most durable type of international orange paint is a chrome orange pigmented linseed oil paint. It is a slow-drying paint used for body and final coats on the exterior surfaces of large buildings. A small amount of spar varnish is included in the paint to retain color; however, the color still has a tendency to fade from exposure.

12-22. Another type, an international orange enamel, is similar in color to the paint above, but it is not as durable; however, it holds its color much better and dries faster. The vehicle in the enamel is glyceryl phthalate synthetic enamel, is a vivid orange red, and is very durable. The color is fast, and the enamel appears best when applied over body coats of the same color. The enamel dries sufficiently overnight to allow sanding and the application of another coat. It is recommended for body and final coats on small metal surfaces.

12-23. *Exterior chrome yellow oil paint.* Exterior medium chrome yellow paint is durable bright yellow paint manufactured for application as a final coat on wood, metal, and masonry. It is used primarily for painting towers and traffic signs. Significant names applied to tints of this paint are: Highway Marking Yellow, Army-Navy Aircraft Yellow, and War Department Yellow.

12-24. *Exterior rust-inhibiting solvent-resistant drum enamel.* Exterior rust-inhibiting, solvent-resistant enamel for coating metal drums is an olive drab semigloss enamel. It is a one-coat system enamel that contains glyceryl phthalate resin, and it dries fast.

12-25. *Aluminum paint mixing varnish.* Mixing varnish is contained in aluminum paint used for priming exterior wood and for general purposes. It is also used for final coats on metal. There are two types of mixing varnish. One type is tung-oil varnish, which is used as the vehicle in aluminum paint for general use. If necessary, for spraying, 1 gallon of aluminum paint containing mixing varnish may be thinned with 1 pint of turpentine. Mixing varnish of high viscosity should be mixed with aluminum paste, and that of low viscosity should be mixed with aluminum powder to bring the paint to the proper consistency.

12-26. *Asphalt varnish.* Asphalt varnish is a general-purpose varnish suitable for covering water pipes, gas pipes, and the like. It is composed of asphalt mixed with drying oils, solvents, and driers. When dry, asphalt varnish has a smooth glossy finish similar to glossy black enamel.

12-27. *Water-resisting spar varnish.* Water-resisting spar varnish is a durable covering suitable for either interior or exterior use. Dried

varnish of this type has a softer film and less luster than some of the other oil type varnishes.

12-28. *Clear and pigmented spraying lacquer.* Clear and pigmented spraying lacquers are used over suitably primed metal and wood interior or exterior surfaces. Repaint jobs should have a sealer or bleeder coat applied before spraying lacquer is sprayed over a color. Ordinarily, spraying lacquer need not be thinned. There are two types of lacquer. One type is clear, and the other is pigmented. A typical clear spraying lacquer consists of a nonvolatile vehicle (15 percent by weight or 10.4 percent by volume). A pigmented lacquer has about 6¼ pounds of suitable pigment added to a clear lacquer.

12-29. *Exterior cold-water white paint powder and liquid.* Exterior cold-water paint powder makes an inexpensive paint that dries to a porous film. It is a breathing type of paint used on masonry surfaces where permeability and durability are as important as beautification. It may be obtained in white or in colors. Linseed oil and spar varnish are often mixed with the water to form the vehicle for exterior cold-water paint and to make the paint more durable. However, special water-dispersible oils are on the market which effect better dispersal of the oil throughout the water than does boiled linseed oil. The paints resulting from either vehicle are equal in quality.

12-30. Cold-water paint is applied to clean masonry surfaces such as concrete, brick, wet walls, etc., uniformly dampened (not wet) before the paint is applied. The paint may also be used on clean primed wooden or metal surfaces.

12-31. *Exterior black oil paint.* Exterior black is a glossy slow-drying paint for final coats on surfaces of exterior wood, masonry, and structural steel. It is a durable paint with excellent hiding qualities when used on structural steel that has been primed and body-coated with two coats of rust-resistant paint.

12-32. *Exterior graphite oil paint.* Exterior black graphite paint is used as body and final coats to cover the primed surfaces of ferrous metals. The graphite in the paint has the property of leafing which accounts for its durability. There are two types of graphite paint. One type is a steel gray paint having a metallic luster. Lamp-black or carbon black is mixed with natural flake graphite, as well as with other types of natural and artificial graphites, and is darker in color.

12-33. The lighter colored graphite paint is intended for body coats, and the darker colored paint is designed for final coats.

12-34. *Red lead oil paint.* Red lead linseed oil paint is a tung-oil gloss paint that is made for priming ferrous metals. This paint keeps well in storage, and is superior to the red lead paint ordinarily mixed on the job. Two coats, one priming coat and one body coat of this paint are preferable for rust resisting purposes.

12-35. *Blue lead oil paint.* Blue lead linseed oil paint is another good priming and body paint for ferrous metals. It is dark gray in color; also, it has good working qualities, and it is durable. As in the case of red lead paint, the metallic surfaces should be given two coats of blue lead paint for rust-resisting purposes.

12-36. *Exterior iron oxide red or brown oil paint.* Exterior iron oxide paint is manufactured in different colors of red and brown. It is an economical paint and is durable. Spar varnish and zinc oxide in the paint increase color retention of the paint and decrease the tendency of the paint to mildew. Iron oxide paint is intended for use on roofs, barns, freight cars, and the like. It is used for body and final coats on metal as well as on wood and masonry. Although not as satisfactory as a rust-resisting agent for ferrous metals, it can be used as a primer on structural steel.

12-37. *Aluminum.* Probably no other paint is used for as many paint jobs as aluminum paint. Aluminum paint is a desirable coating for battleships and large bridges, since the dried film weighs less than half as much as the film of any other common paint. One of its important applications has been in the covering and protection of steel structures and buildings, not only because it is durable but also because it is light in color, reflects light and heat more than any other paint, and has a desirable decorative finish. It is commonly used as a second and finish application over a red lead priming coat.

12-38. When aluminum paint is applied in two or three coats without priming paint to clean and rust-free surfaces, it gives excellent service. When you paint steel, the importance of clean surfaces cannot be overemphasized. Aluminum paint is also used successfully for painting galvanized iron. Without a primer the paint will bond satisfactorily with the galvanizing, provided that the metal has been exposed to the weather for at least 6 months. Aluminum paint possesses excellent durability when used as a priming coat for wood construction. It will cover soft, pitchy and resinous spots very effectively. It is also efficient in the prevention of bleeding of wood stains. Finish coats of light-colored paints may be applied when the correct aluminum paint is used first as an undercoat.

12-39. *Cement-base paint.* This paint comes in powder form and is used on porous interior and exterior masonry surfaces, except gypsum

plaster. There are two types of powder. One type has more hydrated lime and less portland cement than the other. The second type has 80 percent portland cement and 10 percent hydrated lime. The latter type is used for painting inside surfaces of swimming pools, water tanks, etc. Both types contain small percentages of titanium dioxide, zinc sulfate, water repellants, and calcium or aluminum stearate.

12-40. *Plastic paint.* Another type of protective coating that has been introduced on the market in the past few years is plastic. "Plastic" as applied to paints is an abused term. The fact that this word or some variation of it appears in a trade name does not necessarily mean that the product has extraordinary properties. Any of the synthetic resin paints might be called plastic paint because the phenolic, vinyl, and other synthetic resins commonly used in paints are varieties of plastic, compounded with special grades of solution type resins.

12-41. True plastic coatings are now available, and we will discuss some of the common ones briefly. These are tough, flexible coatings that are highly resistant to the natural elements and to many chemicals. They appear to be especially suitable on surfaces when most other coatings have been ineffective. With increased use and improved application methods, costs of plastic coatings are expected to decrease.

12-42. Vinyl resin plastics are being used to a considerable extent as protective coatings. These include plastisols, organosols, and dry, generally powdered, vinyl resins. Plastisols are vinyl resins dissolved in liquid plasticizers which remain as such until heat treated. Organosols are similar to plastisols except that small amounts of volatile solvents are added to improve application properties. Both are high-solids-content materials, the plastisols being essentially 100 percent solids. Fusions of the resins and plasticizers to form plastic film is brought about by raising the temperature of the film between 300° and 360° F. These plastics are used in the manufacture of dishwasher racks, dish drainers, plating tanks and racks, piping and vinyl-on-metal laminates for luggage, instrument cabinets, and furniture—to name a few.

12-43. Other plastics, including the cellulosics, acrylonitriles, acrylics, etc., are being used as protective coatings. These are generally applied by heat processes when the dry resin is fuzed onto the surface to be protected. They are applied as temporary coatings to gears, shafts, screws, and other machined parts during shipment and storage.

12-44. Plastic tapes are also being used for protection on steel pipe. Both self-adhering and those requiring a primer are available. Polyethylene and polyvinyl chloride tapes are the most common ones and are available in 10-, 12-, and 20-mil thickness (20 mils is 20 thousandths of an inch). Wire brushing is generally required to clean the surface, and a primer may be needed before the tape is applied.

12-45. *Floor and deck enamel.* Paint with a varnish vehicle is in reality an enamel; it is intended for body and final coats on primed wooden and concrete surfaces. It is an excellent fast-drying, tough covering that is flexible enough to withstand wear and weather.

12-46. A self primer for wooden floors is made by adding 1 quart of thinning liquid (one part turpentine or mineral spirits and two parts boiled linseed oil) to 1 gallon of floor and deck enamel. Body coats for wooden floors should have 1 pint of boiled linseed oil added to each gallon of enamel. The final coat should be applied as furnished in the container.

12-47. A self-primer for concrete floors is made by adding 1 quart of thinning liquid (one part turpentine or mineral spirits to two parts of spar varnish) to each gallon of enamel. Body and final coats of the enamel are applied to concrete floors as furnished.

12-48. *Bituminous coatings.* Coal tar and asphalt coatings are used extensively as waterproofing, roofing, and for protection of submerged and buried metal pipes and devices. They can be applied at reasonable cost and make a substantial barrier against attack by moisture and oxygen.

12-49. Asphalt coatings are available as enamels, cold applied paints and emulsions. They are considered more resistant to the elements than coal tar.

12-50. *Waterproofing.* Masonry is porous and soaks up water, causing damp interior walls, cracked plaster, peeling wallpaper and paints. Silicone water repellent will usually prevent this problem. A single application (spray or brush) will provide an invisible water repellent surface that will preserve the finish for 5 to 10 years. Oil-base and cement-base paints can be applied over the application. Oil-base paints will destroy the breathing characteristics of the masonry.

12-51. *Swimming pool.* Rubber-base paints are popular for painting swimming pools or other water holding structures; however, water-mix cement base and enamel paints with water-resisting varnish vehicle of synthetic resin are popular. Recent developments have led to the use of epoxies, polyesters, and urethanes which have better resistance to water, chemicals, and abra-

sion than conventional coatings but they are more expensive.

12-52. *Fungicidal.* Fungicidal paints are useful in preserving wood and fabrics by preventing rot. These paints are popular for foundation timbers, sills, fence posts, farm buildings, etc.

12-53. *Fire retardant.* These paints when exposed to flame retard the spread of fire by chemical action of the contents which tends to smother the fire.

12-54. *Camouflage.* Camouflage paints have a dull finish, do not fade, are easily applied, are of low cost, and cover in one coat. Camouflage paints are available in nine colors: light green, dark green, sand, field drab, earth brown, earth yellow, loam, earth red, and olive drab.

12-55. *Traffic paints.* Ready-mixed traffic paint is known as centerline, zone marking, and road marking paint. It is obtainable in white and yellow colors. Both paints are intended for application at a wide range of temperatures to bituminous and concrete highways bearing heavy traffic. Another type of traffic paint is one in which glass spheres are added when the paint is applied to the road surface. This semipaste form of paint, available in various colors, is called a pigmented binder. The glass beads serve as a reflector at night as automobile lights strike them.

12-56. *White wash.* Whitewash is lime paste mixed with water. The paint is inexpensive and is used for covering interior or exterior wooden or masonry surfaces. It is used primarily on brick, concrete, road or roadside obstructions, sheds, telephone poles, and the like.

12-57. Lime paste is made by slaking quicklime in enough water to make a stiff paste and allowing it to cure for several months. The mixing ratios for two good lime pastes are: 20

	HOUSE PAINT (OIL)	TRANSPARENT SEALER	CEMENT BASE PAINT	EXTERIOR CLEAR FINISH	ALUMINUM PAINT	WOOD STAIN	ROOF COATING	ROOF CEMENT	ASPHALT EMULSION	TRIM-AND-TRELLIS PAINT	AWNING PAINT	SPAR VARNISH	PORCH-AND-DECK PAINT	PRIMER OR UNDERCOATER	METAL PRIMER	LATEX TYPES	WATER REPELLANT PRESERVATIVES
CLAPBOARD SIDING	✓.			✓									✓		✓.		
BRICK	✓.	✓	✓	✓									✓		✓		
CEMENT & CINDER BLOCK	✓.	✓	✓	✓									✓		✓		
ASBESTOS CEMENT	✓.												✓		✓		
STUCCO	✓.	✓	✓	✓									✓		✓		
NATURAL WOOD SIDING & TRIM				✓		✓					✓						
METAL SIDING	✓.			✓.					✓.					✓	✓.		
WOOD FRAME WINDOWS	✓.			✓					✓.				✓		✓.		
STEEL WINDOWS	✓.			✓.					✓.					✓	✓.		
ALUMINUM WINDOWS	✓.			✓					✓.					✓	✓.		
SHUTTERS & OTHER TRIM	✓.								✓.				✓		✓.		
CANVAS AWNINGS										✓							
WOOD SHINGLE ROOF					✓											✓	
METAL ROOF	✓.													✓	✓.		
COAL TAR FELT ROOF						✓	✓	✓									
WOOD PORCH FLOOR												✓					
CEMENT PORCH FLOOR												✓			✓		
COPPER SURFACES											✓						
GALVANIZED SURFACES	✓.			✓.					✓.		✓			✓	✓.		
IRON SURFACES	✓.			✓.					✓.					✓	✓.		

✓. Black dot indicates that a primer or sealer may be necessary before the finishing coat (unless surface has been previously finished.)

Figure 42. What paint to use (exterior).

pounds of quicklime to 10 gallons of water; and 50 pounds of hydrated lime to 6 gallons of water.

12-58. Two formulas for compounding whitewash are as follows:

Materials	Formula No. 1	Formula No. 2
Casein	5 lbs	
Trisodium phosphate	3 lbs	
Lime Paste	8 gal	8 gal
Water	6 gal	4 gal
Common salt		12 lbs
Powdered alum		6 oz
Molasses		1 qt

12-59. Figure 42 is a guide showing the type of coating recommended for various exterior surfaces. This chart is designed for general applications, and many times variations must be made.

12-60. The color that is selected for the exterior surfaces should blend with the other structures that are in the area. Often, color selection at an installation is made by personnel other than protective coating specialists.

13. Selecting Interior Protective Coatings

13-1. There are many types of interior coatings available to the protective coater today. These coatings, in addition to being decorative, are designed to use on certain types of surfaces.

13-2. **Type of Surface.** When you select an interior protective coating, you must first consider whether the surface is wood, metal, or masonry.

13-3. *Wood surfaces.* The two-coat and three-coat systems are also employed when you apply oil paint to interior wooden surfaces. Under the three-coat system, approximately 5 gallons of drying oil are added to 100 pounds of white lead paste to compound a priming paint on the job. When the two-coat system is used, about 4 gallons of drying oil are mixed with 100 pounds of white lead paste to compound a priming paint on the job.

13-4. Self-priming paints for interior woodwork may be formulated from the ready-mixed paints used as final coats by diluting one gallon of the paint 25 to 50 percent with drying oil. Slightly more of the drying oil should be added to the paint when the three-coat system is used. Applicable ready-mixing priming oil paints for interior wooden surfaces are obtainable which may be used without basically changing the paint.

13-5. Interior woodwork that is to have a natural finish should be primed and sealed with a ready-mixed varnish or spraying lacquer that has been diluted with the recommended thinner. The varnish or lacquer is applied after the drying oil and filler have been put on and are dry enough to receive the primer-sealer. When interior woodwork is stained, shellac varnish is used as a primer, and sealer to avoid the bleeding of analine stains. Varnish and lacquer may be used as a primer and sealer on other types of stains.

13-6. *Metal surfaces.* When you paint interior metal surfaces, you should use a primer and at least one body coat and one final coat. If more coats are applied, the additional coats are called body coats.

13-7. *Masonry surfaces.* Interior masonry surfaces may be body-coated and final-coated with oil paints or water paints which are used on wood or metal surfaces. Besides color, final coats are selected as to the type of finish desired. Both oil and water vehicle paints that will give a flat finish or an eggshell finish are available. When a gloss or semigloss is desired, the painter usually resorts to oil paints and enamels.

13-8. **Kinds of Coatings.** Listed below are several of the more commonly used coatings for interior surfaces. Note that some can be used on exterior surfaces as well as interior surfaces.

13-9. As with exterior paints, no attempt has been made to list everything that is available on the market. New paints are being developed all the time, and you should make it your business to read about the new products through current publications that deal with protective coatings.

13-10. *Interior cold-water white paint.* Interior cold-water paint powder comes in white or tints. The paint is intended primarily for covering primed wet walls and other masonry surfaces. It is not satisfactory for surfaces which are continually damp, because of its susceptibility to mildew. Surfaces that are to be repainted must be free of calcimine and must have loose or powdering oil paint coatings removed.

13-11. *Primer-sealer floor lacquer.* Lacquer sealer and primer for floors is intended for sealing clean wooden floors that have been sanded. Sealing a newly sanded close-grained or open-grained filled floor helps to fill the wood pores and provides a good foundation (priming coat). The sealer and primer reduce the tendency of the finished surface to mar, integrate the filler and wood, and smooth the surface.

13-12. *Fume- and heat-resisting white enamel.* Fume- and heat-resisting white enamel is intended for use in chemical laboratories, dairies, refrigerator rooms, sewage disposal plants, and areas subjected to temperature or fumes. To avoid discoloration, the paint must be free from lead and iron. This enamel consists mostly of such ingredients as lightproof lithopone, titanium, zinc oxide, or a mixture of these pigments. The

vehicle must exclude any metallic compound driers, but should include linseed, tung, soya, or other drying oils, along with damar, resin, and turpentine or mineral spirits. A softener such as pine oil is used to plasticize the paint.

13-13. Fume- and heat-resisting white enamel will stand some tinting, particularly light gray without discoloring under adverse conditions. The enamel is not as flexible as other white enamels and is less water-resisting than some of the quick-drying enamels.

13-14. *Interior flat white oil paint.* Interior white or tinted flat to eggshell (slight gloss) finish oil paint forms a washable body, which can be used for final coats on primed interior woodwork and masonry. The paint works easily, dries opaque, and has good resistance to scrubbing with soap and water after it has dried for 1 month.

13-15. *Interior gloss white enamel.* Interior white and tinted gloss enamel can be used on interior wood, metal, and masonry that has been primed and body-coated. Such pigments as titanium dioxide, zinc sulfide, and zinc oxide are used in these enamels to obtain the strong opaque white color.

13-16. *Interior one-coat flat white oil paint.* Interior one-coat flat white or tinted oil paint may be applied to the absorptive, porous surfaces of wet and dry walls and woods. This paint contains titanium dioxide or zinc sulfide suspended in a vehicle containing tung oil varnish. The paint comes in a heavy-bodied consistency that is thinned at the ratio of three pints of turpentine or mineral spirits to 1 gallon of paint. It is designed to give uniform coverage without any special primer; however, patched places in plaster or spots that show more porosity should be spot-painted once and allowed to dry before the paint is applied over the entire area.

13-17. *Interior resin-emulsion white paint base.* Interior resin-emulsion paint base comes in white or tints. It is intended for making paints to be used on interior wet or dry walls, masonry, and fabric. The paint may be used on suitably primed wooden and metal surfaces. The object to be body- and final-coated with resin-emulsion paint must be clean; and in case of a repaint job, the old paint must be firm or be removed from the surface.

13-18. The paint is an oil-in-water emulsion product. It is thinned only with water and can be applied by any convenient painting method. The paint dries sufficiently hard overnight to be recoated. Directions for mixing with water are often placed on the container and should be followed. However, in case there are no instructions, the number by parts (by volume) to be added to 1 gallon of water are: for plaster, 2; for very porous surfaces, 1½; and for spraying, 2½.

13-19. *Interior concrete floor rubber-base paint.* A rubber-base paint is made for use on concrete floors subjected to dampness and not exposed to sunlight. The paint should have 1 pint of mineral spirits and 1 pint of toluol mixed with 1 gallon of paint when used as a priming coat. Body and final coats are applied as furnished in the container.

13-20. *Interior cold-water white.* Interior cold-water paint comes in white or tints. The paint is intended primarily for covering primed wet wall and other masonry surfaces. It is not satisfactory for surfaces which are continually damp because of its susceptibility to mildew. Surfaces that are to be repainted must be free of calcimine and must have loose or powdering oil paint coatings removed.

13-21. *Heat-resisting black enamel.* Heat-resisting black enamel is manufactured for use on steam pipes and boiler fronts where temperatures of 400° Fahrenheit or higher are common. The objects to be painted should be cooled below 140° Fahrenheit before paint is applied and they should be held at this temperature for at least 48 hours before being subjected to a higher temperature. There is danger in using this enamel indoors unless the area is well ventilated and away from lights or flames.

13-22. There are two types of heat-resisting black enamel for metal. One type has a bituminous base that is otherwise unpigmented. The other type has a resin base and is pigmented. The pigmented type, besides being heat-resistant, is gasoline- and water-resisting.

13-23. *Luminous.* Luminous paints are used to provide decoration which will glow with a brilliance. Luminous paint in dangerous areas throughout a building will act as safety guides, showing the danger areas even after lights are out. It is similar to the dial and hands of a luminous watch.

13-24. *Waxes.* Wax is available in paste, emulsion, and liquid and forms an important part of the finishing process, especially on furniture and floors. The wax is normally applied over varnish or shellac to give protection to the coated surface. It is often applied directly over sealer to provide a waterproof coating.

13-25. *Linseed oil.* Linseed oil, previously explained in this chapter, may also be used as a finish for wood surfaces. It is ordinarily applied by rubbing.

13-26. *Spirit varnish.* Shellac-replacement spirit varnish is a substitute for shellac varnish and

may be used on interior wood, metal, paper, and fabric surfaces. It may be substituted for oil varnishes where rapid drying is more important than durability. Shellac replacement varnish is almost equivalent to shellac varnish. It can be brushed or sprayed, but it cannot be satisfactorily mixed with oil paints, oil varnishes, lacquers. turpentine, and mineral spirits.

13-27. *Shellac varnish.* Shellac varnish is primarily a sealer and primer for interior wooden and masonry surfaces. Although it is not as durable in some ways as the oil varnishes, some painters use it for body and final coats. It is used occasionally on exterior wood surfaces that are not directly exposed to the weather.

13-28. Shellac varnish is either white (bleached) or orange and is available in light, medium, and heavy bodied consistencies. Both white and orange shellac varnish comes in two grades. One grade is lighter in color than the other and is practically free of rosin and suspended matter. The other grade is darker in color and contains some insoluble matter; therefore, this varnish shellac is used where darker color and some rosin are not objectionable.

13-29. One thinner for varnish shellac consists of a mixture of five parts of methyl alcohol to 100 parts of ethyl alcohol. Another thinner consists of one part of aviation gasoline and five parts of denatured ethyl acetate to 100 parts of denatured alcohol.

13-30. *Orange shellac.* Orange shellac is used in making shellac varnish. Several grades of orange shellac are processed and placed on the open market. The highest grades are known as superfine and by other names. The second highest grade is called fine or by other names. The third highest grade is called pure T.N. This grade is rosin-free and darker than the higher grades. The lowest commercial grade is U.S.S.-ATN and contains some rosin. This grade may

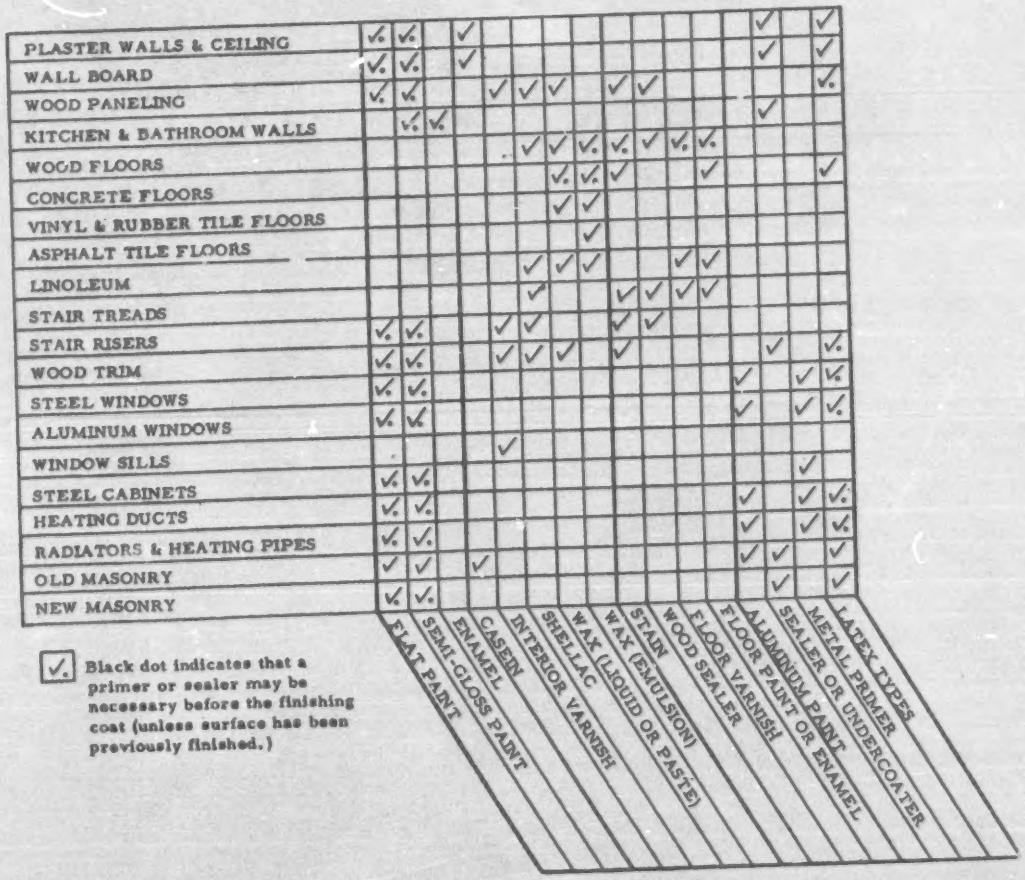


Figure 43. What paint to use (interior).

be darker in color than the two highest grades, but lighter than the grade just above it.

13-31. *Interior damar varnish.* Damar varnish is a spirit varnish made for use as a final coat on interior surfaces. It is also used by manufacturers as a vehicle for some white and tinted enamels used for covering interior metal surfaces, such as radiators, exposed to high temperatures. It is not satisfactory for surfaces that are exposed to moisture and abrasion.

13-32. *Primer-sealer floor varnish.* Varnish sealer and primer, used for treating wooden floors and cork floors and coverings, furnishes a good foundation for other coats of varnish and for wax. The varnish aids in filling the pores of close-grained wood and filled open-grained wood. There are two classes of this varnish sealer. One class is made for use on the close-grained woods, and the other is used on open-grained filled woods. Varnish sealer and primer is actually a thinned out spar varnish, because a good spar varnish may be used as a sealer and primer when it is thinned with turpentine or mineral spirits equal to one-half its volume. This mixture is similar to the class of varnish sealer and primer made for open-grained wood. When cut with equal amounts of thinner, the spar varnish is about the same consistency as the varnish sealer and primer made for close-grained wood.

13-33. *Interior varnish.* Interior varnish is manufactured for use on inside woodwork and floors, except where the varnish is required to have rubbing qualities.

13-34. *Interior cabinet-rubbing varnish.* Cabinet-rubbing varnish is intended for interior wooden surfaces where a rubbed finish is desired. It is not a baking varnish for metal, nor is it a suitable varnish for floors.

13-35. Figure 43 is a guide showing the type of coating recommended for various interior surfaces. This chart is designed for general application, and many times variations must be made. It is always wise for the protective coating specialist to read the label on the container to make certain the coating is compatible with the surface and primer being used.

14. Handling, Storing, and Disposing of Protective Coatings

14-1. The protective coating specialist must know how to store, handle, and dispose of protective coatings efficiently and safety. Proper knowledge of these duties will prevent overage stocks, opening of wrong containers, and incompatible paint jobs. Furthermore, you can prevent accidents and injuries by learning safe disposal methods.

14-2. **Handling Protective Coatings.** When handling paint containers, be careful not to damage the labels. Paint labels have valuable information on them, such as the date the paint was manufactured, its color, type, etc. Without this information, large amounts of paint could be wasted or misused. If the labels are damaged, replace them with the correct information.

14-3. **Storing Protective Coating Materials.** These items should be stored, whenever possible, in dry, fire-resistant, well-drained, and well-ventilated structures, preferably separated from other buildings, and under automatic sprinkler protection. You should not use space heaters and other direct fired heaters to heat storage areas. Floors should be concrete and drained to one point. The drain should run to a sump or detached cistern and have a deep trap. The storage structure should be ventilated with screened inlet air vents 6 inches above the floor and screened outlet vents through the roof. This will allow paint fumes to escape. You should provide protection for paint containers against wetting by rain, snow, steam leaks, or other sources of water.

14-4. To avoid direct heat on the materials, they should not be stored near steam lines or other sources of heat. It is recommended that steam heat be used with heating coils above the stock, with the coils screened to prevent them from contacting the containers. You should not store paint on floors below grade (ground level). In any case, you should lay the first tier of containers at least 2 inches above the floor level to allow suitable ventilation and drainage.

14-5. Paints and paint thinner packaged in 55-gallon steel drums may be stored outdoors provided the containers are protected against rusting. This is done by painting the bare metal areas and setting the drums on dunnage (scrap lumber) so as to provide approximately 2 inches clearance above the ground. Drums stored out of doors should be laid on their sides to prevent the loss of the markings stenciled on the heads caused by weather-action of rain, snow, and ice.

14-6. Paints and paint thinners must be stored separately from other materials such as grease, oil, and spare parts. Rags, wood, and other similar combustible material must not be stored in the same building with paint.

14-7. Containers of paint materials should be readily accessible at all times. Other materials must not be stacked on top of paint materials. Containers should be stored and issued in order of the dates of manufacture shown in the respective labels. Material bearing the oldest date is used first. If date of manufacture is not shown on the container, the date of receipt may be

considered as the approximate date of manufacture for purposes of storage and issue.

14-8. For best results the temperature of paint materials should be between 65° and 85° F. (room temperature range) at the time of use. If storage conditions result in paint temperatures being below 55° F. or above 95° F., the container should be stored at room temperature for approximately 24 hours prior to use.

14-9. Containers of paint may develop internal pressure from high temperatures. This condition is apparent as a bulging of the light gage "tin" containers but is not evident in the heavier gage steel drums. Therefore, containers must be opened with care to allow the pressure to dissipate slowly before the seal is completely removed. Failure to observe this precaution may result in your being spattered by paint exploding because of a sudden release of pressure.

14-10. Containers sealed with bungs are opened by turning out the bung slowly until a hissing sound is heard. When the hissing ceases, indicating equalization of pressure with the atmosphere, the bung can be completely removed.

14-11. Containers that are bulged or misshapen from internal pressure should have a small hole punctured in the top to release the pressure. Use a fine, nonspark producing tool, such as aluminum or copper. Signs should be posted on the storage building to read

"FLAMMABLE—KEEP FIRE AWAY."

14-12. **Disposing of Protective Coating Materials.** When paints and chemicals become old, dried out, or contaminated with foreign matter, they must be disposed of. They are not discarded like other waste material. They should be taken to the sanitary fill, opened, and then tossed into the fill. When acids become contaminated or have served their purpose, you should bury them about 2 feet deep in a designated disposal area. Remember, chemicals are dangerous; therefore, follow all directions and procedures when you use or dispose of them.

Protective Coating Equipment

PROTECTIVE COATING equipment has been developed and improved until today the technician must know how to use, maintain, and store a variety of equipment ranging from paint brushes to traffic marking machines.

2. If the protective coater knows how to select and maintain the large variety of equipment and tools that are available today, he can do his job more efficiently and save many man-hours.

15. Surface Preparation Equipment

15-1. Before you apply any protective coating it is most important to prepare the surface. You have heard the old adage—a chain is only as strong as its weakest link—a protective coat is only as good as the surface it is applied to. If the surface is scaly, dirty, oily, or dusty, the coating will not adhere satisfactorily.

15-2. **Manually Operated Tools.** There are a great many hand-operated tools for the protective coater to use. We will discuss only those that you are most *likely* to use in your work.

15-3. **Wire brushes.** Wire brushes such as those shown in figure 44 are used to remove loose paint from wood, masonry or metal surfaces in close places and where power equipment cannot be operated economically. They are made of different sizes and shapes, some having a large gage wire bristle, some small, depending on the stiffness required. Some of the bristles are made of steel to be used on steel, wood, masonry, etc.; some are of brass to be used on brass, stainless to be used on stainless steel, etc. Brushes should be stored by hanging on a wall so that the bristles will not be damaged.

15-4. *Painter's dusters.* Painter's dusters are usually flat or oval in shape and are fitted with a handle similar to a paint brush. They are used to remove fine dust before painting. Store them by hanging them on a wall or wrapping paper around them and laying them flat. Never stand them on the bristles.

15-5. *Scrapers.* One type of scraper is used to remove deteriorated paint from the surface (see fig. 45); another is used to remove plane marks and mill marks from wood surfaces (see fig. 46). Scrapers that are made of flexible steel must be kept sharp to do good work. Hand scrapers are sharpened as shown in figure 47. A cabinet scraper is shown in figure 48 and a scraper plane in figure 49. The cutting edges of these scrapers are sharpened similarly to the hand scraper. Never toss the scraper into a toolbox with other tools as this will nick the sharp edge and make it necessary to resharpen.

15-6. *Putty knives.* (See fig. 50.) Among the many different styles of putty knives that are available, there are those with short, stiff blades; some with long, flexible blades; some wide; and some narrow. The original purpose of the putty knife was to glaze window panes into window frames, but it is often used to scrape old paint surfaces and to apply joint cement to sheetrock walls. Putty knives seldom need sharpening, but should be stored in a manner to prevent damage to the blade.

15-7. *Cold chisels.* Cold chisels such as shown in figure 51 are used to chip paint and scale from metal surfaces. Cold chisels are available in different widths and lengths. Sharpen the chisel on a grinding wheel by restoring the bevel, which is usually 60° to 70°. Sometimes it is also necessary to remove the burrs from the head if it has mushroomed.

15-8. *Files.* A file is a steel tool used for cutting and smoothing metals and wood. A wood rasp is a coarse file that differs from the ordinary file in teeth shape and size. There are over 3,000 types and kinds of files and rasps. The most common types are shown in figure 52. Files are cleaned with a file card (a wooden handle with a brush on one side and fine wire teeth on the other). Preserve the sharpness of files and rasps by storing them in a rack. If it is necessary to carry files in a toolbox, wrap them individually in cloth or paper to protect the teeth. Keep them

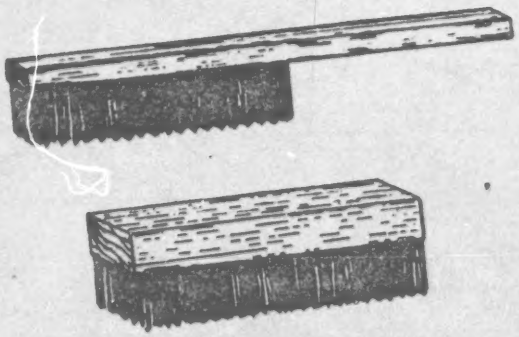


Figure 44. Hand wire brushes.

dry to prevent rusting. Do not use rust preventive compound. Files are very brittle, so do not hammer them or use them as pry bars.

15-9. *Abrasives.* There are many different types of abrasives and each type has a variety of grit size and use. Among the types available are flint, garnet, emery, aluminum oxide, and silicon carbide.

- Flint is used mostly by painters because of low cost, but it dulls and wears quickly.
- Garnet is a natural mineral and is the choice abrasive for hand sanding and finishing wood.
- Emery is a natural mineral that comes from Turkey and Greece. It is a good cutting agent, but slow. It is used mostly for metal polishing and rust removing.
- Aluminum oxide with production paper backing is used on both wood and metal surfaces because its tough coating cuts faster and longer than flints.
- Silicon carbide is produced by fusing silica and coke. Its sharp abrasive is used on lacquers, plastics, composition materials, and metals for both wet and dry sanding.

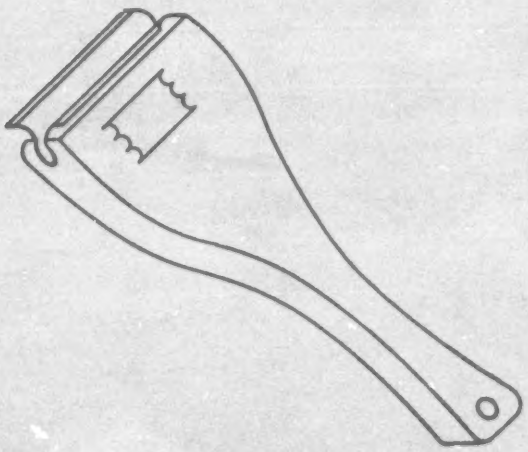


Figure 45. Paint scraper.

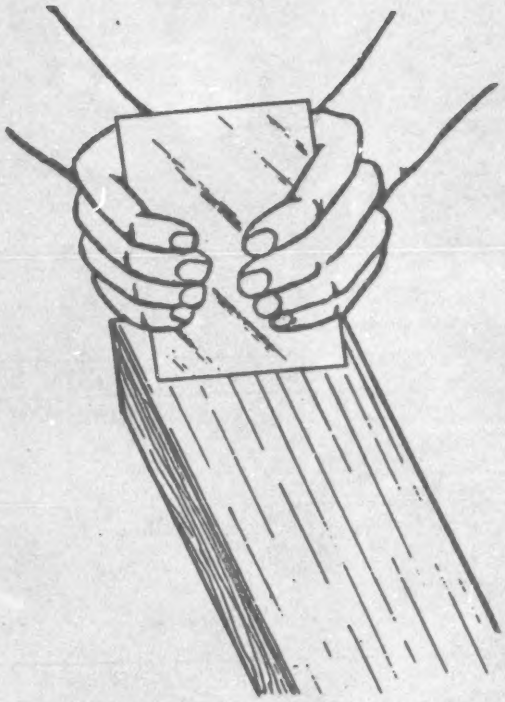
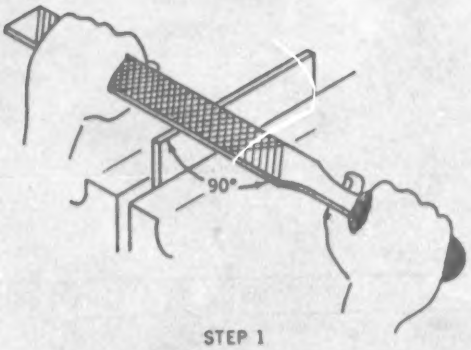


Figure 46. Wood scraper.

15-10. The abrasives are fastened to paper, cloth, or fiber and are available in sheets, belts, and discs for use on sanders. Paper backing comes in four popular weights: A is soft and flexible and is used where flexibility is desired; C and D are thicker and used where flexibility is not necessary; E is heavier and is used mostly for machine sanding. Cloth backing comes in two weights: J is used with emery for hand sanding, while X is used mostly with power tools.

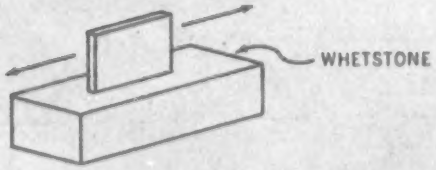
15-11. Until recently manufacturers listed their abrasives by numbers, but it was a complicated system, so now they have started labeling their paper fine, medium, coarse, etc. Figure 53 shows the corresponding numbers and grit comparisons. Figure 54 is a guide to help you select the correct type and size of abrasive.

15-12. In addition to these abrasives, there are three powdered abrasives—pumice stone, rottenstone, and jeweler's rouge—that are used mostly in furniture, or fine woodwork finishing to smooth the finishes between coats and to polish metal surfaces. Pumice stone comes in grades "F," "FF," "FFF," and "FFFF." "FFF" is the best



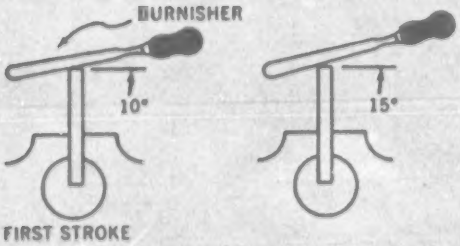
STEP 1

(a) DRAWFILING



STEP 2

(b) WHETTING EDGE



STEP 3

(c) TURNING THE EDGE WITH A BURNISHER

(d) EDGE READY FOR USE

Figure 47. Sharpening a scraper.

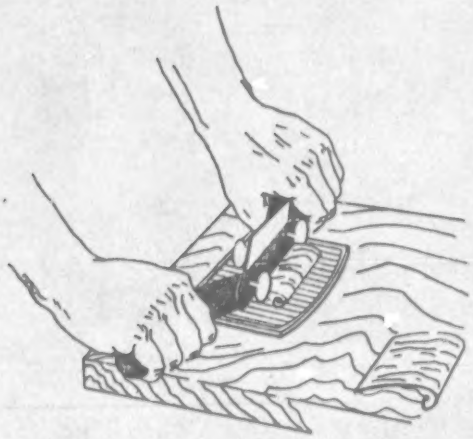


Figure 48. Cabinet scraper.

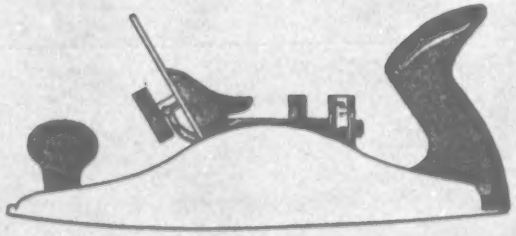


Figure 49. Scraper plane.

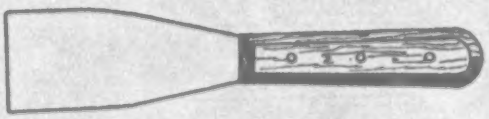


Figure 50. Putty knife.

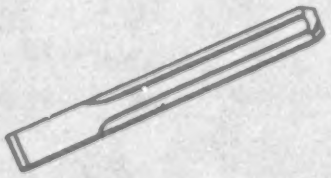


Figure 51. Cold chisel ¾".

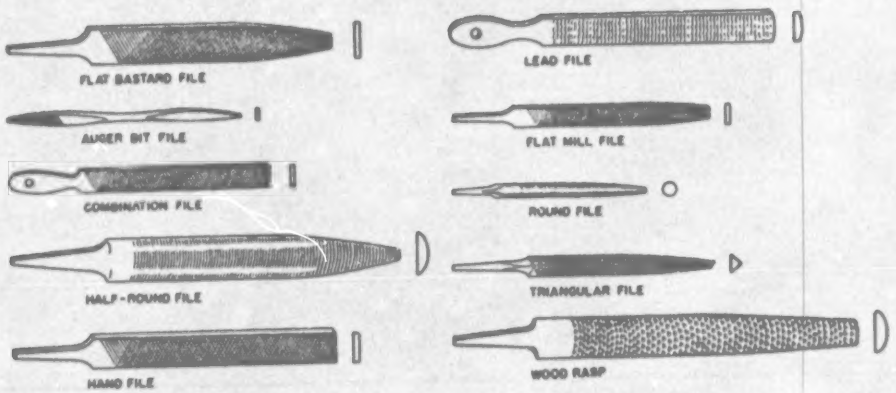


Figure 52. Files.

all around powdered abrasive to use. Rottenstone and jeweler's rouge are available in one grade only.

15-13. *Metallic wool.* Metallic wool has a variety of uses and in many areas it is better than abrasives. There are four major types of metallic wool: aluminum wool for use on aluminum; copper wool for use on copper; stainless steel wool for use on stainless steel; and steel wool, the most common type, is used on steel, iron, tin, and wooden surfaces. Metallic wools come in six grades from No. 3, the coarsest to 3/0 the finest. Figure 55 is a guide to help you select the correct grade of steel wool.

	Garnet and Aluminum Oxide	Flint
Superfine	10/0--400	
Extra fine	9/0--300	
	8/0--280	
	7/0--240	
Very fine	6/0--220	4/0
	5/0--180	3/0
	4/0--150	2/0
Fine	3/0--120	
	2/0--100	0
Medium	0--80	1/2
	1/2--60	1
Coarse	1--50	1 1/2
	1 1/2--40	2
Very Coarse	2--36	2 1/2
	2 1/2--30	3
	3--24	

Figure 53. Abrasive grit number comparisons.

15-14. *Blowtorches.* A blowtorch as shown in figure 56 can be used to remove paint from interior and exterior surfaces. Blowtorches are available in many forms and use gasoline, alcohol, acetylene, or petroleum gas for fuel.

15-15. A blowtorch is filled by turning it upside down and unscrewing the filler plug. Unleaded gasoline is poured into the base which serves as a funnel. When the tank becomes full, replace the filler plug and wipe off the excess gasoline. (Leaded gasoline will clog the torch.) Turn the blowtorch upright and operate the air pump to put pressure on the gasoline in the reservoir. Pour a small amount of gasoline in the bowl below the vaporizing assembly and ignite it. Gasoline can also be placed into the bowl by opening the valve a small amount and allowing gasoline to drip into it. When the gasoline in the bowl is almost burned, open the needle valve and the torch will light.

15-16. A blowtorch can be dangerous if not used correctly.

- Never light a blowtorch in an unventilated room.
- Always set a blowtorch on a solid surface while lighting it.
- Never move a blowtorch while gasoline is burning in the bowl below the vaporizing unit.
- Never light a blowtorch in the wind.
- Do not use near draperies or curtains.
- Keep away from windows as the heat will crack the glass.
- Always go back over your work to make certain that no fire exists.

15-17. In addition to the conventional blowtorch, torches are available that use pressurized petroleum. These torches are very convenient, especially for removing paint from smaller areas.

Abrasive	Coarse	Medium	Fine	Use
Aluminum Oxide	2 1/2-1 1/2 1 1/2 1 1/2-1 3-2 1/2	1/2-0 1/2-0 0-2 1/2 1/2-0	2/0-3/0 2/0 2/0-3/0 2/0	Hardwood Aluminum Copper Steel & Sheet Metal
Garnet	2 1/2-1 1/2 1 1/2-1	1/2-0 0	2/0-3/0 2/0	Hardwood Softwood
Flint	3-1 1/2	1/2-0		Removing paint and rough scale

Figure 54. Selecting proper abrasives.

	GRADE	USE
Very Fine	000	Final Smoothing
	00	Between Coatings (with oil)
Fine	0	Most Commonly Used
Medium	1	General Purpose
	2	Rough Work
Coarse	3	Restoration Work

Figure 55. Selecting steel wool.

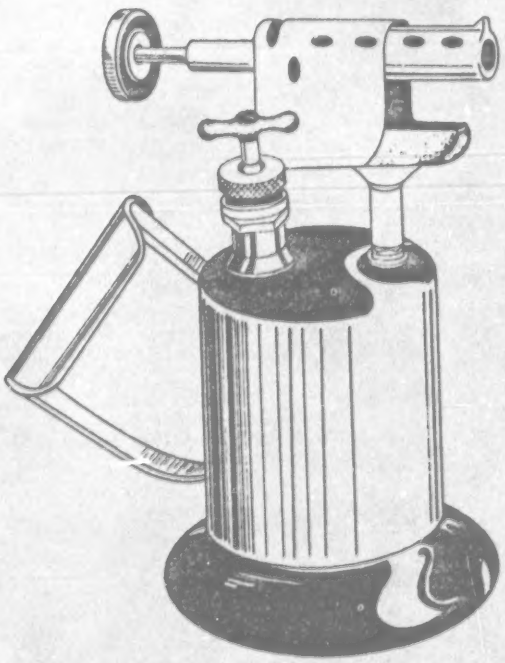


Figure 56. Blowtorch.

15-18. *Caulking guns.* Caulking guns come in two different styles. One is cartridge loaded and the other is loaded by unscrewing the end and fitting with bulk compound. The gun is used to (1) fill cracks between window and door frames and the wall of the building, (2) fill cracks in masonry surfaces prior to painting, and (3) fill the crack between baseboards and interior woodwork and wallboard prior to painting. It is also used to disperse asbestos or fibrous roofing cement when you stick asphalt roofing shingles. After using either type, make certain the gun is clean, as the compound will harden and ruin the gun.

15-19. **Power Tools.** In areas where power tools can be used, much time and effort can be saved through their use. Also, in some cases, the same power unit can be utilized for several operations by using special attachments. For example, one power unit can accommodate a grinder, sander, or a buffer.

15-20. *Power wire brushes.* If the area is very large, power wire brushes should be used to conserve man-hours. Power wire brushes are used to remove paint from wood, masonry, or metal surfaces, and corrosion from metal surfaces.

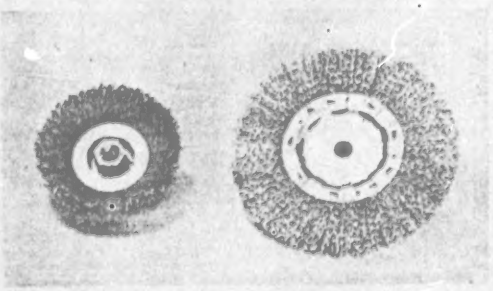


Figure 57. Power brushes.

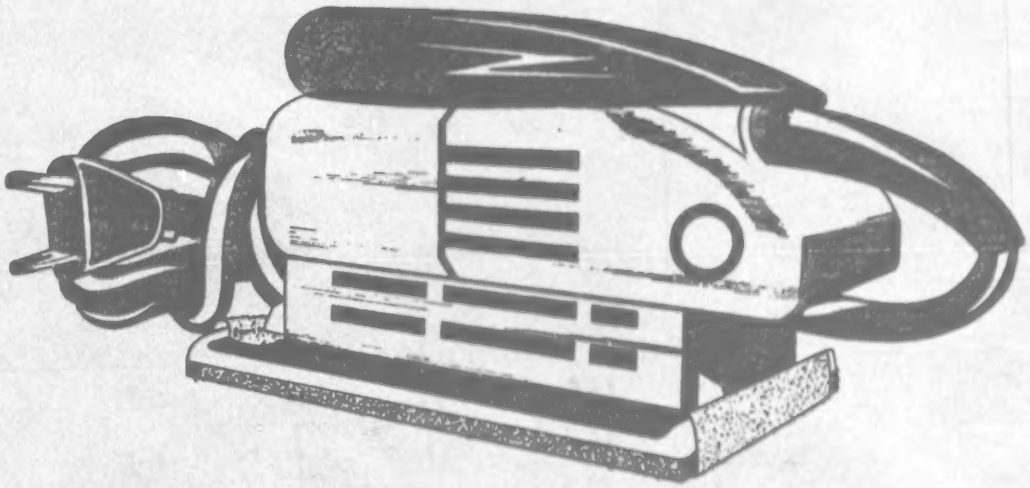


Figure 58. Orbital vibrator sander.

Brushes of fine spring steel should be used. Figure 57 shows two types of wire brushes that can be used on an electric or air motor, flexible shaft machine or in the chuck of an electric drill. They can also be mounted on a stationary or portable grinder. No maintenance is necessary but when the brush wears down, replace it.

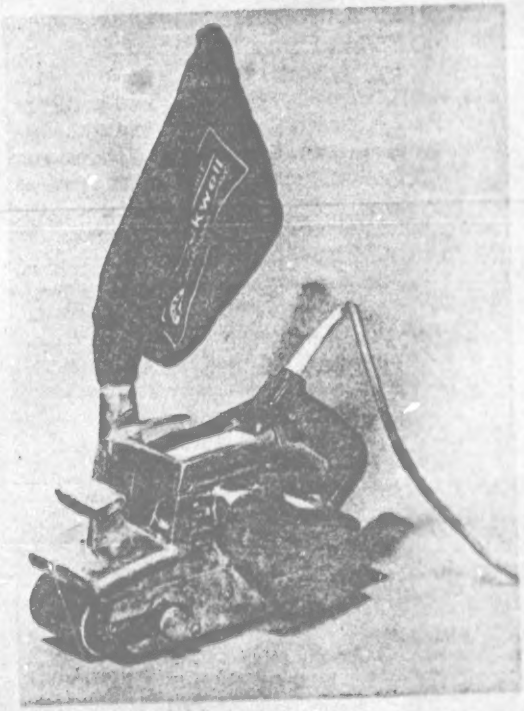


Figure 59. Portable belt sander with dust bag.

15-21. *Power sanders.* The power sander is used to remove paint and corrosion from metal and wood surfaces and to smooth the surface for finishing. There are many types of power sanders available, but the sanders that you will use most are the portable vibrator, belt, disc, and the drum floor sander and floor edgers. You must wear safety goggles or a face mask while using these machines. All portable sanders should be started before placing them on the work.

15-22. A portable vibrator sander (electric) is a small machine into which a sheet of abrasive is clamped. An orbital vibrator sander as shown in figure 58 is small enough to hold in one hand while sanding. This tool is excellent for removing old paint and varnish and such work as sanding of drywall joints. No maintenance is necessary on this machine.

15-23. The portable belt sander (fig. 59) uses and endless abrasive-coated belt which runs over two flat pulleys. It requires both hands to operate. It is used for production finishing and for fast and efficient sanding of wooden surfaces.

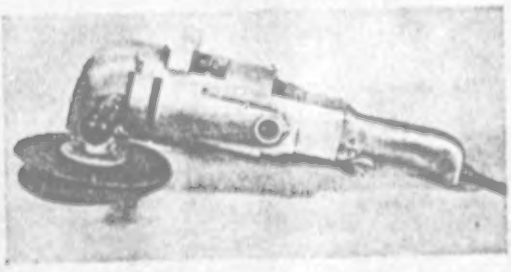


Figure 60. Portable disc sander.

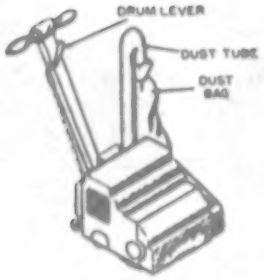


Figure 61. Floor sander.

Extreme caution must be taken so that the sander will not cut too deeply. Clean the sander with compressed air occasionally.

15-24. The portable disc sander (fig. 60) is used mostly on metal surfaces or to remove badly flaked paint on wood surfaces. One type is available that will fit the chuck of an electric drill or power tool. The abrasive discs come in various grits for various tasks and can be replaced easily.

15-25. The drum floor sander (fig. 61) uses an abrasive belt, similar to the belt sander. The sander is used to sand new and painted wood floors; however, because of its size, it cannot sand close to the walls and in corners. An edger is used for this purpose. The only maintenance required is to blow compressed air through the motor occasionally and replace the belt when it becomes worn.

15-26. The floor edger (fig. 62) is very similar to the portable disc sander; in fact, the abrasive disc is interchangeable. The floor edger is designed so that it will sand close to the walls and in corners, eliminating much hand sanding. Clean by blowing compressed air through the motor occasionally.

15-27. *Power buffers.* There are two types of power buffers; one type is used to buff wood floors and the other type is used to put a high polish on metal surfaces. They are cleaned in the same manner as other power equipment by removing dust from the motor with compressed air.

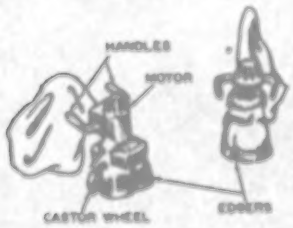


Figure 62. Floor edger.

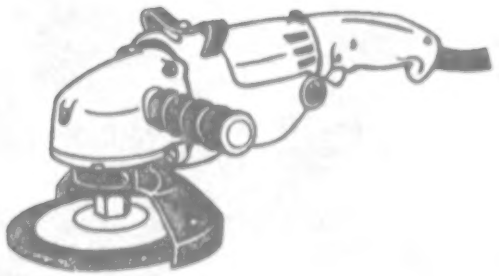


Figure 63. Portable power grinder.

15-28. The floor buffer weighs approximately 30–40 pounds. The polishing pads vary in size from 12″ to 22″ and are made of nylon or animal hair and hog bristle. The pads can be obtained in coarse, medium, and fine.

15-29. The metal buffer is a rag wheel that can be installed on a power tool or a bench grinder or it can be used with a flexible shaft machine or in a portable drill equipped with a special chuck. The rag wheel is charged with buffing compounds (jeweler's rouge, rottenstone, or pumice), and it is essential that you wear a face mask and gloves to protect you from fine particles that come from the wheel. The fine ravelings from the wheel are turning at a high rate of speed and are capable of cutting flesh.

15-30. *Portable power grinders.* The power grinder is used to remove scale and encrustation from metal surfaces. The tool, as shown in figure 63, is driven by an electric motor that uses 110-volt, 60-cycle alternating current. The electric motor in the grinder is geared and has a chuck so that you can attach different grit size abrasive wheels. The action of the grinder may be clockwise or counterclockwise. Goggles are a must when you use a grinder, and the safety guard must be in place. Reinforced abrasive wheels must be used and the operating speed indicated on the wheel blotter must not be exceeded.

15-31. *Descaler.* A descaler is an electric or pneumatic hammer with a multiple-needle head. The needles can be interchanged with a chisellike unit. This tool is good for cleaning hard-to-get-at areas on metal surfaces, such as grooves, corners,

Figure 64. Descaler.

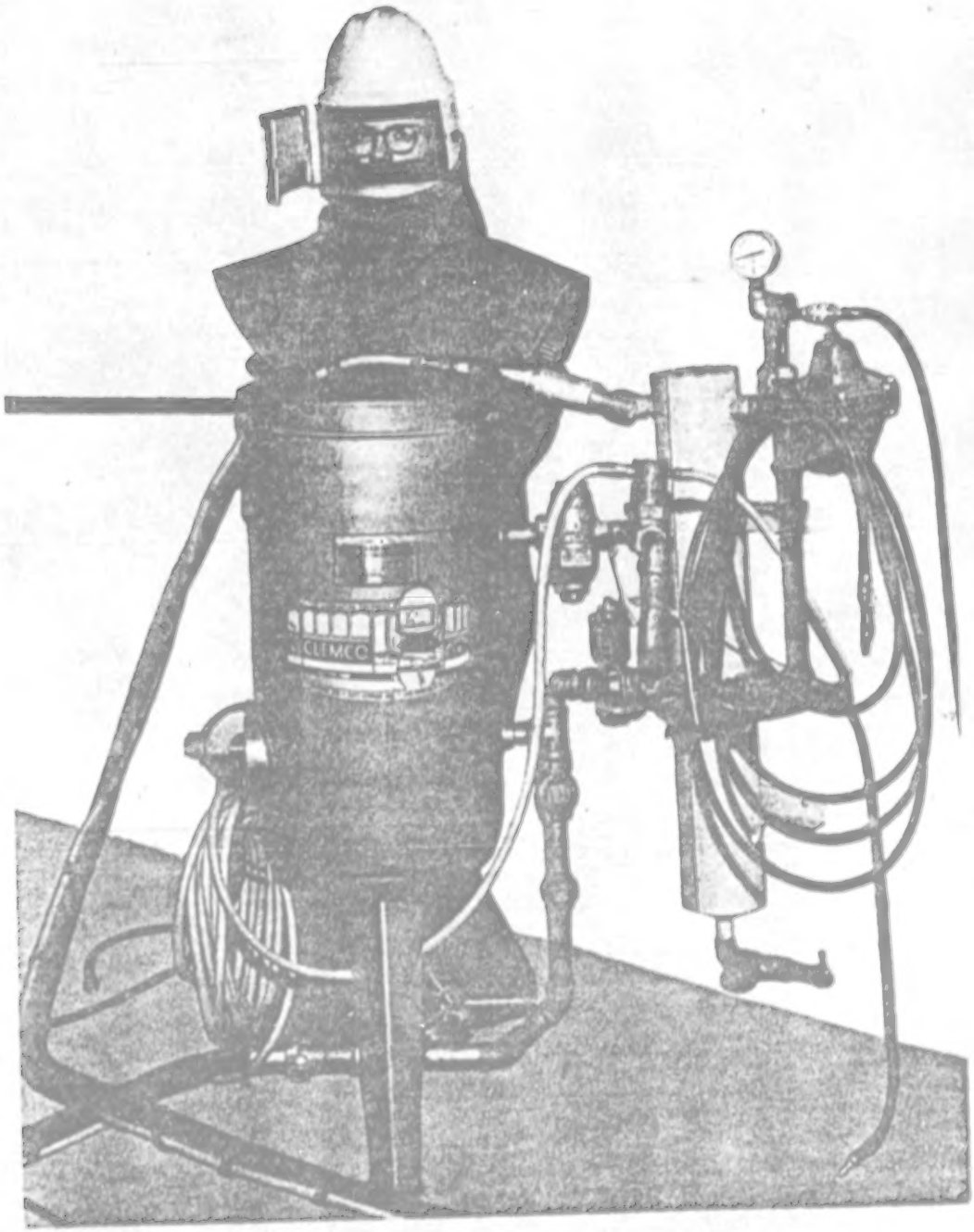


Figure 65. Abrasive blaster.

crevices, rivets, protruding nuts and bolts, and gratings. (See fig. 64). The descaler operates with a reciprocating action, its wear-resistant alloy needles hammering the surface clean. This tool weighs approximately 4½ pounds and is 14–20 inches long. When using this tool, wear goggles and a face shield or a hood.

15-32. *Portable abrasive blasters.* The portable abrasive blaster, as shown in figure 65, is used to remove paint from metal or masonry surfaces and corrosion from metal surfaces. It is a very effective method of removing traffic markings from concrete paving.

15-33. Abrasive blasting equipment is simple to operate. In fact, only 8 to 16 hours operating time is required by an operator with no previous experience to acquire a basic knowledge of abrasive blasting techniques. However, simple though the operation may be, each type of equipment has its own peculiarities, and the operating instructions of that type of equipment should be followed closely to prevent damage to the equipment or to the material being cleaned.

15-34. The abrasive blaster is operated by compressed air. The air pressure bombards the surface with the abrasive (sand, grit, splitshot, or glass beads) at high velocity. If the compressed air is furnished by a portable compressor, the manual for operating this particular type of compressor must be followed.

15-35. Before attempting to start the blaster, check the abrasive hopper control to make certain it is in the closed position. It is also very important that you check the attachment of the electrical ground wire of the abrasive hose, since abrasive cleaning produces static electricity, which is a fire hazard, particularly around dust areas.

15-36. You must wear complete head and face covering at all times and be provided pure, oil-free air for breathing when blasting in confined areas.

15-37. The operator maintenance on a typical blaster consists of checks at each 5 hours of operation, daily, and each 20 hours of operation.

a. 5 hours operation. Disassemble the blast gun and inspect the nozzle for wear and cracks. Replace the nozzle when inside diameter (ID) exceeds ⅜ inch or when it is cracked.

b. Daily. Remove and fill the chamber screen.

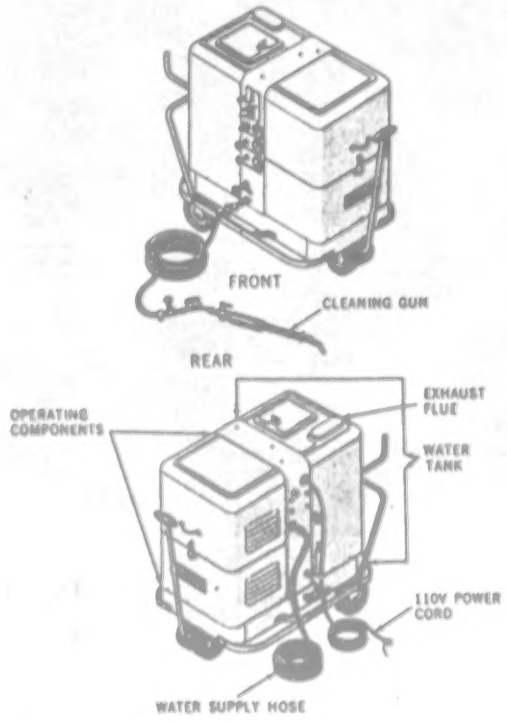
c. 20 hours operation. Depressurize the blast generator, place the choke relief valve in the abrasive flow position, and remove the mixing valve. Disassemble the valve and inspect the diaphragm, valve seating surfaces, and the passageways for abrasions and ridgings. Replace worn parts as necessary and reassemble-reinstall the mixing valve. Remove the cover on the swing check valves (2 each) and make certain that the flapper seats and operates freely.

15-38. When the unit is not to be used for sometime, discharge leftover abrasive through the gun. Open the drain valve at the bottom of the hopper to remove the small quantity that is below the level of the pump inlet.

15-39. Remember that the above instructions are for a typical unit and that you must check your operator's manual on your specific blaster, as each unit has its own peculiarities.

15-40. *Portable vacuum blaster.* The portable vacuum blaster is used for the same purpose as the abrasive blaster. One big advantage of the vacuum blaster is that the used abrasive, debris, and dust are removed by vacuum during the blasting process.

15-41. *Steam cleaner.* The steam cleaner (see fig. 66) consists of a metal cabinet that houses such components and systems as an electric motor (or gasoline engine), a water system, a soap system, and a heating system. The steam cleaner blends the detergent with water and pumps the solution into a heating unit, where it is partially vaporized. The heat plus vaporization generates



96 Figure 66. Steam cleaner.

pressure in the system. The solution is then directed to the cleaning hose and gun from which it is sprayed upon the surface to be cleaned. The detergent and spray, together with impact (friction) caused by high velocity, loosen and remove dirt and encrustations. After the cleaning operation is finished, vaporized spray can be converted into a solid, high velocity stream of water to rinse the material being cleaned.

15-42. *Vacuum cleaners.* You can use an industrial or domestic vacuum cleaner to remove dirt, dust, small loose objects, paper, etc., from surfaces and areas before applying protective coatings. A soft bristle brush on the inlet of the vacuum cleaner will help to loosen caked soils.

15-43. Always remember to check the applicable technical order or operator's manual when you (1) use any of the above-listed items of equipment and (2) when you perform maintenance on equipment.

16. Application Equipment

16-1. As a military protective coating specialist, it will be your job to apply protective coatings to buildings and other structures. It is therefore necessary that you know how to select the best methods and equipment to do a satisfactory job faster and safer, and the most economical for the military. It is understandable that power equipment should be used whenever it is feasible. To avoid duplication, equipment which is used for both surface preparation and application has been included only once in one or the other of the categories.

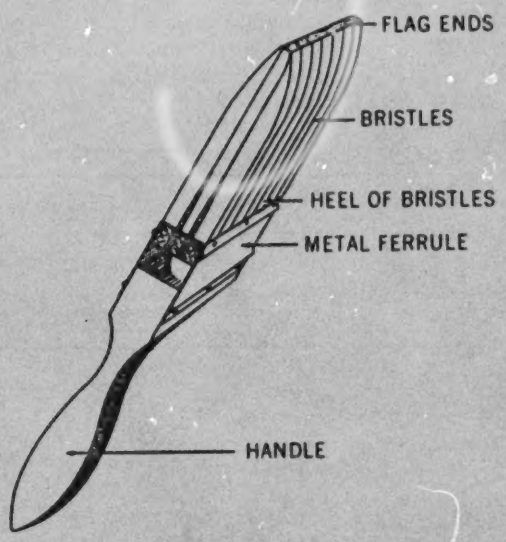


Figure 67. The principal parts of a paint brush.

Figure 68. Flag end of hog bristle.

16-2. **Hand Paddles.** Hand paddles are used by the painter to keep his paint well mixed while he is painting. Paddles are usually made of wood so they can be discarded after using—saving a cleaning job; however, more efficient metal paddles with holes in the blade are available. It is not economical to mix large quantities of paint with a paddle if a power mixer is available.

16-3. **Power Paint Mixers and Shakers.** Power paint mixers and shakers were covered in Chapter 2, paragraphs 10-22 through 10-24.

16-4. **Paint Buckets.** Several plastic buckets that will hold at least 1½ gallons are very useful to mix paints and clean brushes after using them. A paint can extender also is a handy item when you stir paints in the original paint container.

16-5. **Paint Strainers.** A paint strainer is necessary when you use paint that has set all night. When you mix dry pigments and oils it is necessary to strain the mixture before using. A strainer is also used to strain any coating that is to be used in a spray gun. Some strainers are made of paper and cloth. They are inexpensive and should be disposed of in a fireproof container after use. Others are made of fine wire mesh which must be cleaned with the same material that is used to thin the mixture.

16-6. **Paint Brushes.** It is important for a protective coating specialist to be able to select a good quality brush of the correct size and shape for a particular job and it is also important to know how to care for a brush, how to store it properly, and how to reclaim a brush after it has been abused.

16-7. *Selection of brushes.* Besides choosing a good quality paint brush, you should also select a brush that is the right size and shape for the job. For example, using a small brush on large surfaces not only wastes energy but also prevents the proper spreading of paint.

16-8. A good quality brush is needed if you are to do a good job of applying paint to a smooth surface. A good quality brush is well bristled, and the bristles are springy. Figure 67 shows the principal parts of a paint brush. A poor quality brush will neither hold well nor spread

the paint evenly. Good quality bristles are made from natural or synthetic bristles, or a mixture of these materials. The bristles of good quality brushes are flagged at the ends to hold paint and help spread it. (See fig. 68.)

16-9. A brush made of hog bristle is suitable for applying enamels and oil-base paints to produce a smooth finish on either interior or exterior surfaces. The hog bristle is a tapering hollow tube that forms natural flag ends. The flag end of each bristle is like a little brush. These flag ends pick up and carry a large amount of paint. They also help to spread the paint evenly on the surface. Hog bristles wear away and continuously form the flag ends as the tube splits.

16-10. A brush made of nylon bristle is suitable for use in applying water-thinned and oil-base paints to both interior and exterior surfaces. This synthetic-type bristle is tapered and possesses the resiliency and toughness required for painting operations. Nylon bristle is similar to hog bristle, except that the ends of nylon bristles are sanded to make them flag. After they are once flagged, they will continue to flag naturally as the bristle wears away.

16-11. Do not use nylon bristles to apply lacquer, since the solvents will ruin the bristles. In general, cleaners containing strong solutions of acid, alcohol, or phenolics are injurious to synthetic bristles.

16-12. A brush made of horsehair is a substitute for a hog bristle brush. It is made from the manes and tails of horses and does not have the elasticity and life found in hog bristle. Horsehair does not retain its stiffness when immersed in oil and paint. It lacks toughness, strength, and wearing qualities and does not hold paint well.

16-13. Brushes are available in various sizes and shapes. Some are flat, some are oval, some are angular cut and some are chisel shaped for special purposes.

16-14. Brushes for applying paint and stain to large wall surfaces, both interior and exterior, are flat and 3 to 6 inches wide. Wall brushes are ¾ to 1½ inches thick and have bristles from 2 to 7 inches in length. They are usually square-ended and square-edged, with the natural bend of the bristles bending toward the center of the bristle (see fig. 69).

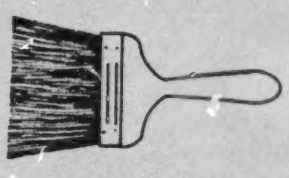
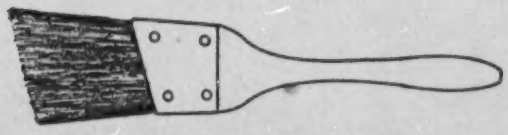


Figure 69. Flat wall brush.



ANGULAR CUT SASH BRUSH

BEVELED SASH BRUSH

Figure 70. Sash and trim brushes.

16-15. Sash and trim brushes (see fig. 70) vary in shape and size but most are narrow width, 1 to 3 inches. One type has bristles that are beveled like a cold chisel to get close to window panes. One type has an angular cut used by some painters (see fig. 70) when painting hard-to-reach spots. Another type preferred by some painters is almost oval in shape.

16-16. Brushes as shown in figure 71 are used for varnish, shellac and lacquer and are usually chisel shaped which contributes to smoother application and prevents lap marks. This type brush usually comes in a 2- to 4-inch width and with extra fine bristles 4 to 6 inches in length.

16-17. *Care of brushes.* All brushes contain a few short bristles which are not caught in the setting. These should be removed from the brush before it is used by striking the bristles against the spread fingers of your hand. It is also a good idea to dip a brush in the thinner used for the paint and then shake the thinner out before starting to paint. This keeps the paint from hardening on the surface of the bristles and makes cleaning easier.

a. Never stand brushes, wet or dry, on their bristles. The bristles will set in a curve, and no amount of effort will restore them to their original condition.

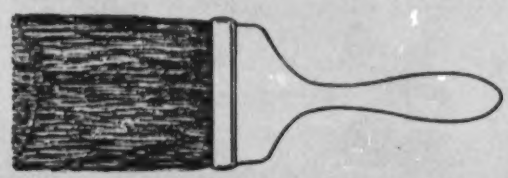


Figure 71. Varnish brush.

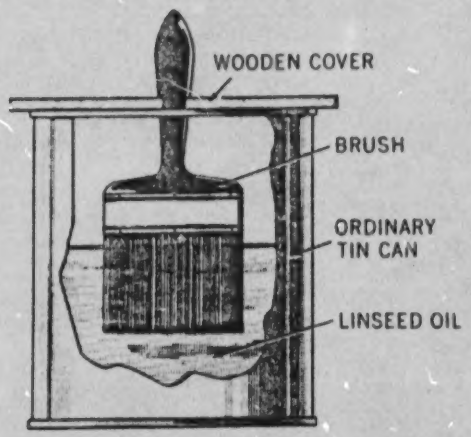


Figure 72. Brush keeper.

b. Do not rub the bristles over the edge of the container to remove excess materials, as this procedure tends to wear or break them. Instead, tap the brush lightly against the inside of the container above the paint level.

16-18. *Cleaning of brushes.* To keep brushes soft and pliable, you should clean them immediately after use. Once material has been allowed to harden in a brush it is extremely difficult to restore it to its original pliability. The best brush cleaners are the solvents used to thin coating materials. To clean a brush, you should:

- Squeeze out as much of the paint as possible.
- If some paint has hardened in the brush, soften and work it out.
- Pour some solvent into a container, work solvent thoroughly into the bristles, make sure that it gets to the base of the bristle.

16-19. *Storage of brushes.* All paint brushes in daily use should be kept overnight in a brush keeper, as illustrated in figure 72. Immersion of cleaned brush bristles in proper oil solvent or thinner will assure you that the bristles will remain soft and pliable.

16-20. Use linseed oil for oil paint and varnish brushes, lacquer thinner for lacquer brushes, and alcohol for shellac brushes. Use sufficient solvent material to cover the bristles of all the brushes. And remember, brushes in the keeper should not touch the bottom or each other. When brushes are not to be used for a length of time, they may be prepared for storage as follows:

- Clean thoroughly and immerse in raw linseed oil for a short time.
- Remove and press out most of the oil. Wrap in oiled paper and store flat with no weight on the bristles.

16-21. *Reclaiming of brushes.* To reclaim a paint-hardened brush, soak it in a commercial cleaner or a paint remover. A mixture of equal quantities of alcohol, acetone, and benzol is also used to soften paint-hardened brushes (other than nylon). Leave the brush in the solution until the bristles are soft and pliable. If the bristles are badly bent, soak the brush in machine oil and lay it on a heated piece of metal until the oil in the bristles sizzles. While the brush is still hot, reshape and bind the bristles with metal strips of wire. After the brush has cooled, wash it in mineral spirits and rinse it with benzol or acetone. Then wrap the brush in paper.

16-22. **Paint Roller Coaters.** Paint roller coaters are available in different types. The types

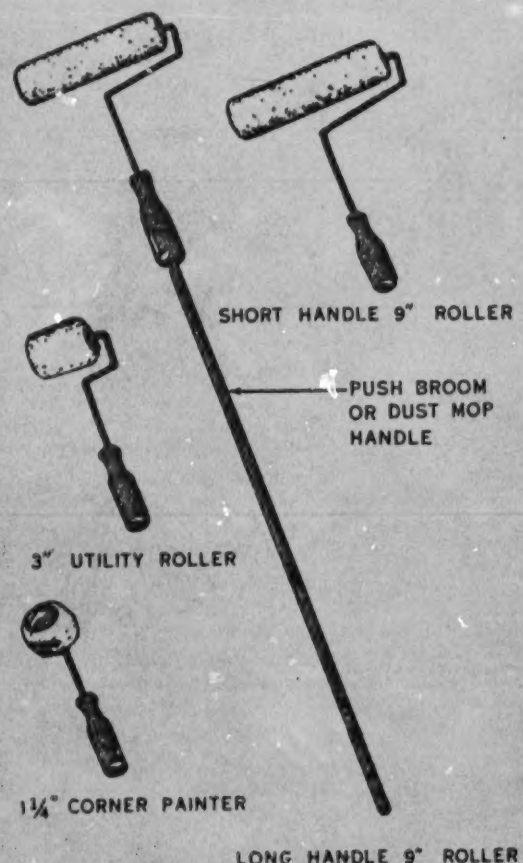


Figure 73. Roller coaters.

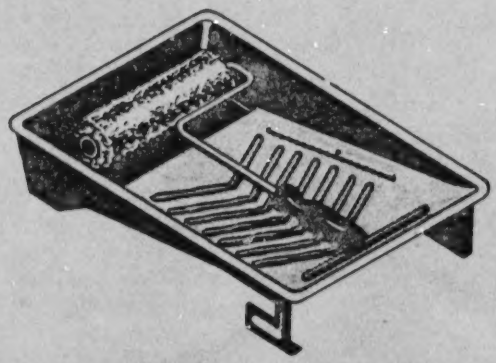


Figure 74. Roller coater and pan.

most commonly used are lamb's wool, mohair, stippler, and high-pile.

16-23. The lamb's wool cover is used for general-purpose painting. The mohair cover is especially effective with enamels and rubber-base paints. The stippler is used to produce a deep stipple finish. The high-pile cover, sometimes referred to as a long-nap cover, is designed for painting rough surfaces such as brick, stucco, concrete, concrete blocks, tile, siding, shingles, fences and other uneven surfaces.

16-24. The size of rollers used will depend on where you are painting. Small rollers, 1¼ and 3 inch, are used to apply next to windows and door openings and at corners where it is difficult to use larger rollers.

16-25. Figure 73 shows the most common sizes and types of roller coaters. Industrial rollers are available in widths up to 18 inches. The handles of the roller coaters are designed to accommodate a push broom or dust mop handle so that floors can be painted without kneeling, and ceilings and high places can be reached without the use of scaffolding.

16-26. Most roller coaters are constructed so that the covers can be removed from the holder for cleaning. The materials used for cleaning the cover depend upon the type paint being used. For water paint, use soap and warm water; for enamel, use mineral spirits or turpentine followed by soap and water; and for shellac, use denatured alcohol, followed by soap and water. Dry the roller thoroughly before storing. When the cover becomes worn or unusable, replace it with a new one.

16-27. **Paint Roller Coater Pans.** Paint roller coater pans are usually shallow, rectangular containers made of metal. They are used to apply paint to the roller. These pans vary in size, depending upon the width of the paint roller. The pan must be wide enough to place the roller in it, as shown in figure 74. Note the ridges formed on the bottom of the pan which control the amount of paint that stays on the roller when it is pulled over them. The pan is cleaned with the same materials as the rollers and is often used as the container for the fluid to clean the rollers.

16-28. **Painter's Dusters.** Painter's dusters are usually flat or oval in shape and are fitted with a handle similar to a paint brush. They are used to remove fine dust before painting. Store them by hanging them on a wall or wrapping paper around them and laying them flat. Never stand them on the bristle.

16-29. **Paint Spray Guns.** There are many variations of paint spray guns: the internal mixing type and external mixing type, suction feed or pressure feed, bleeder or nonbleeder, and attached container or a separate container. Each spray gun may be a combination of any of the variations listed.

16-30. *Internal mixing type.* The internal mixing type spray gun mixes the paint and air inside the gun and spray cap, as illustrated on the left side of figure 75. The internal mixing type cap requires less air pressure than the external mixing type and is popular on small units. The main fault of the internal mixing feature is that fast-drying materials atomized inside the cap tend to collect inside and around the outlet. Pressure feed spray guns are usually of the internal mixing type.

16-31. *External mixing type.* The external type spray gun mixes the paint and air outside of the gun spray cap, as illustrated on the right side of figure 75. Spray guns are also of the bleeder and nonbleeder type.

16-32. *Bleeder type.* A bleeder type spray gun is constructed in such a way that air passes through it at all times. This feature prevents excessive pressure buildups in the compressor. If a spray gun is to be connected directly to a small compressor, it should be of the bleeder type.

16-33. *Nonbleeder type.* This type of gun is used in conjunction with a compressor that will automatically shut off when the pressure reaches the desired setting. When the trigger on the gun is released, air through the gun is stopped.

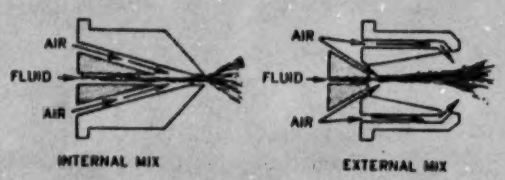


Figure 75. Internal and external paint guns.

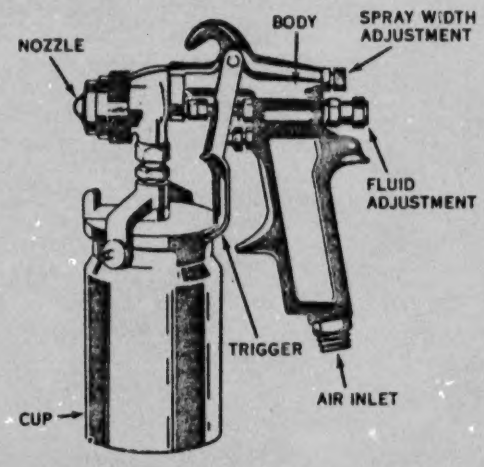


Figure 76. Attached container type spray gun.

16-34. *Suction feed.* A suction feed spray gun is one in which pressurized air passes over the tip of a fluid tube, sucks fluid from it, and sprays it into the airstream.

16-35. A suction feed spray gun can be identified by the presence of an air vent hole in the paint cup cover. The suction spray gun is ideal for small areas to be sprayed with lacquer, varnish, and other light materials. However, this gun should be avoided when heavy paint is to be sprayed, since it will not pull heavy materials up to the nozzle.

16-36. *Pressure feed.* A pressure feed gun is made with an airtight container. Pressurized air directed into the container places the fluid under pressure and forces it up the fluid tube, and at the same time sprays the fluid.

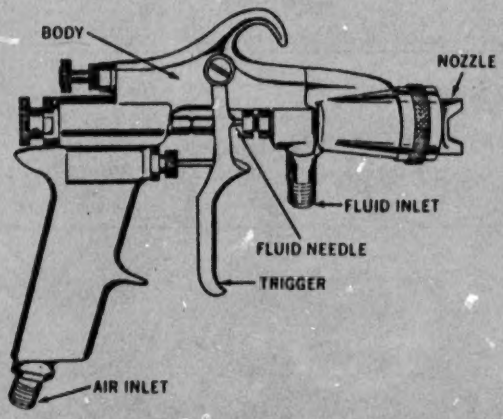


Figure 77. Separate container type spray gun.

16-37. A pressure feed gun will spray heavy paints and materials when supplied with a low volume of air. It is considered one of the best general-purpose guns for use with regular paints.

16-38. The mechanisms of pressure and suction feed guns are the same, and both types can use internal and external mixing of the fluid and air. Since no siphoning effect is necessary for pressure feed application, it is the tool for volume painting.

16-39. *Attached container type.* An attached container type spray gun is usually referred to as "cup type," since the paint is held in a cup attached to the bottom of the gun. Cup type guns, which require only an air hose, are used extensively in military painting. The gun is illustrated in figure 76.

16-40. *Separate container type.* A separate container type spray gun does not have a paint container or cup attached to the lower portion of the gun. It is illustrated in figure 77. This gun receives paint materials through a fluid hose from a separate container called a material pressure feed paint tank.

16-41. Pressure feed paint tanks are large metal containers that provide a constant flow of paint material at uniform pressure to the paint spray gun. The spray gun is connected to the tank with two hoses, one for air and the other for paint material. These tanks range in size from 2- to 60-gallon capacities. (See fig. 78.) Basically, they consist of a container with a clamp-on lid, an air pressure regulator, and connections for fluid and air.

16-42. In actual operation, air pressure from a compressor or some other air supply is forced into the paint tank. This air pressure causes the paint to flow out of the tank through a fluid hose to the spray gun. When the paint reaches the gun head, it comes in contact with air passing through the spray gun which atomizes and sprays the paint.

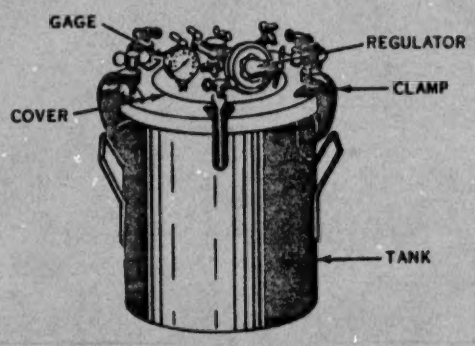


Figure 78. Pressure feed paint tank.

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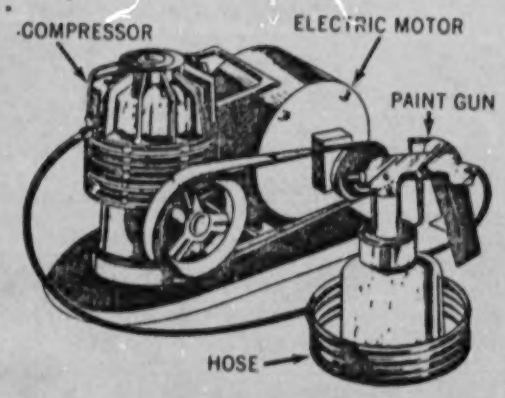

Figure 79. Low-pressure spray unit.

16-43. Paint spray guns and pressure feed paint tanks must be thoroughly cleaned after each use. To clean spray guns and tank units, and hoses, wash and wipe out the tanks or spray gun cups, pour a small amount of solvent or thinner into them, reassemble and apply air pressure until the thinner has been blown through the hose and gun. Finish by wiping off the units with a cloth moistened with solvent or thinner.

16-44. When paint and air passages become clogged with paint, it is necessary to disassemble the units and soak all metal parts in thinner or paint remover. After the thinner or paint remover has softened the paint in the air and paint passages, take a soft wire of the appropriate size and work it back and forth through the passages until they are open and clean. Do not use lye or any other caustic alkali solution for cleaning paint spray equipment.

16-45. Whenever paint guns and tanks are to be stored for an indefinite time, the surfaces of moving parts should be given a thin film of oil. Lubricate the spray gun air valve daily with light oil. Keep all spray gun packings, such as the fluid needle packing, soft and pliant by occasional oiling.

16-46. **Air Hose.** Air hoses are usually lightweight, flexible, and kink-free, and will withstand pressures as recommended by the manufacturer. Air hoses should be of the proper size to furnish the proper amount of air. For proper operation of spray gun equipment, the gun must receive an adequate supply of compressed air.

16-47. **Fluid Hose.** Fluid hoses are usually made of synthetic rubber and are used with all

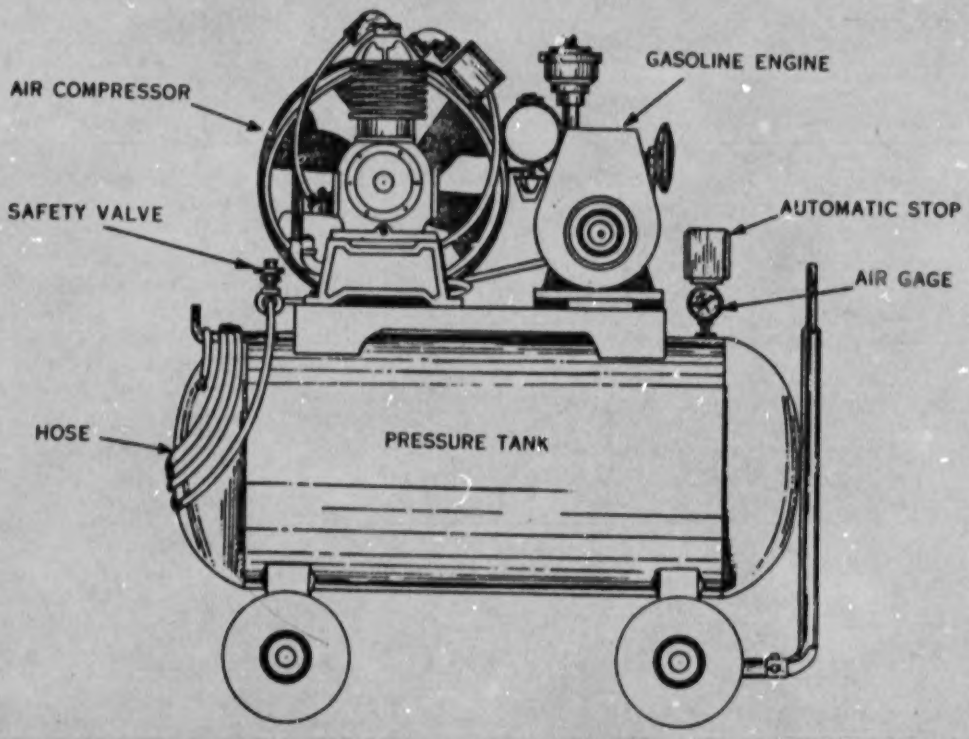

Figure 80. High-pressure spray unit.

types of painting materials, solvents, and oils. Fluid hoses are cleaned at the same time as the gun when thinner or solvent is forced through them by air pressure.

16-48. Air Compressor Units. An air compressor unit is a mechanical unit designed to continuously supply compressed air at a specific pressure and volume. Usually, the Army painter will be concerned with two types of compressor units, the low-pressure unit and the high-pressure unit.

16-49. *Low-pressure spray units.* The electric motor-driven, low-pressure paint spray unit, illustrated in figure 79, weighs approximately 50 pounds. The overall weight of this unit includes the air pressure pump, the air pressure tank, and the driving unit. The driving unit may be either a gasoline engine or an electric motor. Since the low-pressure spray unit is designed to operate on a pressure from 20 to 40 psi, caution must be exercised not to apply higher pressures. Because of the low-pressure operation of this gun, it is not recommended for spraying quick drying paints, lacquers, or enamels.

16-50. *High-pressure spray units.* High-pressure spray units are used for large jobs where heavy duty spray equipment is required. They are driven by both gasoline engines and electric motors. A typical gasoline engine driven unit is shown in figure 80. A unit of this type consists of the same basic components as the low-pressure paint spray unit. Usually, these units are completely automatic and hold a working air pressure between certain low and high limits (80 and 100 psi). The compressor is large enough to deliver air at a volume of 5 cubic feet per minute at a pressure of 80 to 100 psi. The larger air receiver or pressure tank, for the same unit, will satisfactorily deliver an air volume of 7 to 8 cubic feet per minute at a pressure of 80 to 100 psi.

16-51. The only maintenance services needed on an air compressor are cleaning the air filters and servicing the crankcase. Some compressors may require additional lubrication by means of oil cups, grease cups, or grease gun fittings.

16-52. If electricity is available, electric motors are more satisfactory than gasoline engines for driving compressors as they require very little maintenance.

16-53. Where electric power is not available, a gasoline-driven unit must be used. The preventive maintenance services for the gasoline engine are similar to those for any gasoline engine. The lubricating oil in the crankcase must be kept at the proper level. If it is low, add enough to bring the level up to the full mark. In addition, the oil in the crankcase must be changed and if the engine has an oil filter, the filter cartridge is usually changed when the oil is renewed. The air filter should also be cleaned as recommended by the manufacturer. Be sure to check the manufacturer's handbook or applicable technical order for operating instructions and maintenance of the particular type of equipment that you have.

16-54. **Airless Spray Equipment.** In an airless spray system, as shown in figure 81, the spray is created by the forcing of paint through a restricted orifice at very high pressure. Atomization of the paint occurs without the use of air jets, thus the name airless spray. Liquid pressures from 1900 to 2600 pounds per square inch (psi) are developed in special air operated high-pressure pumps and delivered to the gun through a single hose line.

16-55. The system provides a very rapid means of covering large surfaces with wide angle spray without overspray mist or rebound. The single small diameter hose makes gun handling easy. The spray produced has a full wet pattern for quick film buildup, but requires extra care in lapping and stroking to avoid excessive coverage that would result in runs, sags, and wrinkles.

16-56. The system shown is operated by compressed air, but electrically operated models are available, which are very convenient if electric power is available.

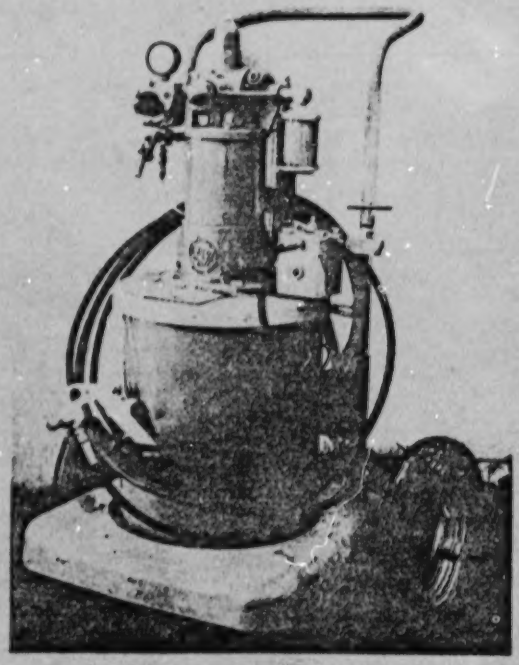

Figure 81. Airless spray equipment.

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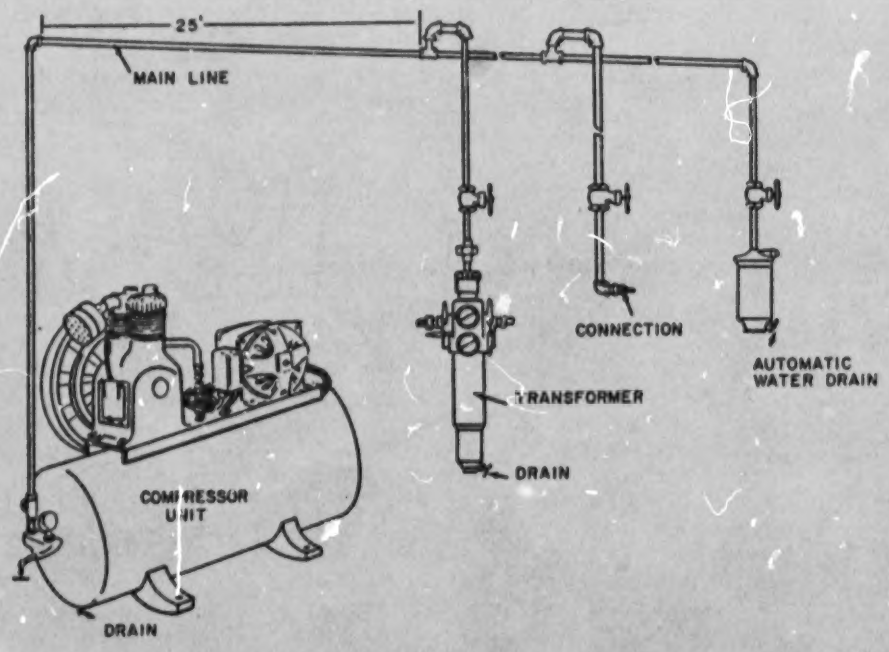

Figure 82. Stationary compressing unit.

16-57. Because of a static electrical potential generated by the high pressure necessary for airless spraying, it is possible that sparking may occur between gun and object being sprayed. This can result in explosion and/or fire. Be sure that both the object being sprayed and the airless equipment are grounded. This can be done by attaching a static wire to ground. If the hose does not contain a static electrical conductor, a static wire must be attached from spray gun to ground.

16-58. Under no circumstances should paint be permitted to set up, settle out, or dry within the pump. Routine maintenance and cleaning should be done daily as follows:

(1) The motor section is lubricated lightly at time of manufacture. Moisture condensing on the cylinder wall during compressing action when pump is operating is cause for further lubrication. However, if an air line lubricator is installed, it should cause no trouble as long as the amount of oil used can be controlled.

(2) Wipe the inside of the container with a lacquer solvent soaked rag. The container is coated with clear lacquer to inhibit rust. Any solvent not compatible with lacquer may cause congealing.

(3) Shut off the air supply to the pump by turning the adjusting knob on the regulator counterclockwise until no spring pressure is felt. Remove pressure from the system by either pulling the trigger on the gun or by opening the pressure release valve on the fluid strainer assembly by turning clockwise.

(4) Detach the main air supply hose from the stem at the regulator and attach to the stem on the lift assembly. This lifts the pump assembly from the fluid container.

(5) Remove the fluid container, clean, fill with approximately 1 gallon of clean solvent and replace the pump.

(6) Remove the spray cap and strainer assembly from the spray gun and clean with solvent used during painting operation.

(7) Detach the main air supply hose from the stem on the lift and attach to the stem at the regulator. The pump will lower back into the container.

(8) If the pressure release valve was opened to relieve the system pressure, be sure to close it at this point.

(9) Turn the adjusting knob on the regulator clockwise just far enough so that the pump will operate slowly when the gun trigger is pulled.

(10) Aim the nozzle of the gun against waste material and hold the trigger back until fluid in the pump, hose, and gun has been replaced by solvent.

(11) Aim the nozzle of the gun back into the solvent container, pull the trigger and circulate

the solvent in this manner until the fluid remaining in the system is suspended in solvent. Cleaning action will be better if the system pressure is increased at this point. Lift the inspection cap on the container cover assembly and aim the nozzle into the container.

(12) Repeat step (3).

(13) Turn the handle on the filter cartridge one full turn. Do not turn the handle while filter is pressurized or distortion of the unit cartridge will result. If the handle turns hard, it should not be forced, but the unit cartridge should be removed for thorough cleaning.

(14) Repeat steps (4), (5), (7), (8), and (9) respectively, using clean solvent.

(15) Open the pressure release valve and allow the solvent to circulate for a few seconds.

(16) Repeat steps (3) and (4).

(17) Empty the container and clean the exterior of the pump and container with a solvent soaked rag.

(18) Wipe off the entire unit with a dry rag.

(19) Detach the hose connection from the stem on the lift and allow the pump assembly to settle into the empty container.

(20) Turn off the air supply.

16-59. **Stationary Compressor Unit.** In a paint shop or aircraft hangar where compressed air is furnished by a large stationary compressor, the air lines leading to the spray guns should be inclined. This is done to permit the condensed moisture from the compressed air to flow back into the air pressure tank. Figure 82 shows the installation of a stationary compressing unit with the air line sloping toward the air compressor. In this manner, the water is drained by the drain cock at the base of the air pressure tank.

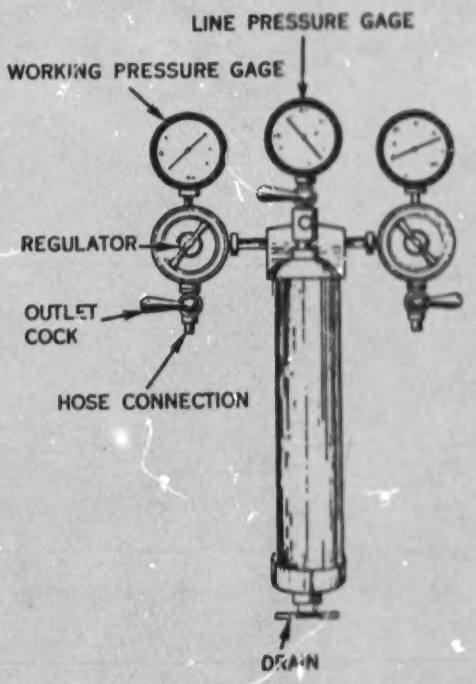

Figure 83. Air transformer.

16-60. **Air Transformer.** Since spray guns must be supplied with clean, moisture-free, regulated air, a special device must be installed in the air line to perform this job. The device is called an air transformer, illustrated in figure 83 with all its parts named. The air transformer has three functions: (1) it separates oil, dirt, and water from the compressed air before it enters a spray gun; (2) it reduces main line pressure to any desired working pressure for a spray gun; and (3) it provides convenient hose connections for one or more spray guns. The transformer is usually provided with gages which indicate the working pressures at the outlets.

16-61. Whenever an air transformer has only one working pressure regulator, all attached spray guns will have the same working pressure. However, if the transformer has two working pressure regulators, as shown in figure 83, the attached spray guns may be regulated to different working pressures.

16-62. An air transformer should be used in all finishing or refinishing paint shops where a supply of clean, moisture-free regulated air is required. Your paint shop may use an air condenser to separate oil and moisture from the air. A condenser is used where a regulated supply of air is available.

16-63. The conventional spray systems have basic similarities necessary to their efficient operation. There must be an adequate source of compressed air, a supply of paint, and a spray gun for controlling the combination of air and paint in an atomized cloud against the surface to be coated.

16-64. **Spray Booth.** A permanent spray paint shop requires a well-ventilated and well-illuminated spray booth. Figure 84 illustrates a portable spray booth that is ventilated by the deflector plate shown in the back. It is illuminated by floodlights recessed in the walls of the booth. Portable floodlights should also be available for the spray booth; they provide good illumination directly on the area being painted. All lights used must be of the vaporproof type.

16-65. **Wiping Rags and Dropcloths.** Wiping rags should be carried at all times by the protective coater to wipe up spills and splatters on

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Figure 84. Portable spray booth.

unprotected surfaces before they dry. Dropcloths are available in canvas, rubberized fabrics, plastic, and sometimes impregnated paper. They are used to protect furniture and floors. Plastic dropcloths are the most popular because they are inexpensive and can be discarded when they become soiled.

17. Traffic Markers

17-1. Traffic markers are used to paint stripes on roads, parking lots, and landing strips and to paint curbs. Stripes can be painted on roads, etc., by hand with the use of a guide, but it is a slow process. If a power operated marker is available, it will save a lot of manpower.

17-2. **Construction Features.** Power-operated traffic marking machines differ in design and construction. Each manufacturer builds one or more machines to certain specifications with their own power, but some do not have a traction drive. Such machines must be pushed by hand or pulled by a motorized truck or tractor. A few of the machines are designed to be mounted on motorized trucks; others are mounted on either three or four wheels, operate on their own power, and furnish power for traction.

17-3. A typical small, power-operated, self-propelled traffic marker is shown in figure 85. This machine is compact in construction, with all of the units in plain view. The paint tank is located between the wheels, with the gasoline engine and air compressor mounted over it. The paint spray gun is located on the right front side. The bead dispenser hopper is mounted in front and to the right of the engine and compressor. A flexible hose connects the hopper with a rotating bead spreader. The front wheel furnishes the traction for the machine. Power is transmitted to the wheel from the engine by roller chains.

17-4. Machines of this type are used to paint traffic stripes and dispense glass spheres into the wet paint in one operation. They may have any number of spray guns and sphere dispensers, depending upon the make and model.

17-5. The air compressor may be of the single or twin cylinder type, capable of delivering ample air pressure. The safety valves are generally set at 75 to 100 psi.

17-6. The paint tanks vary in capacity with the type of machine. All paint should be strained

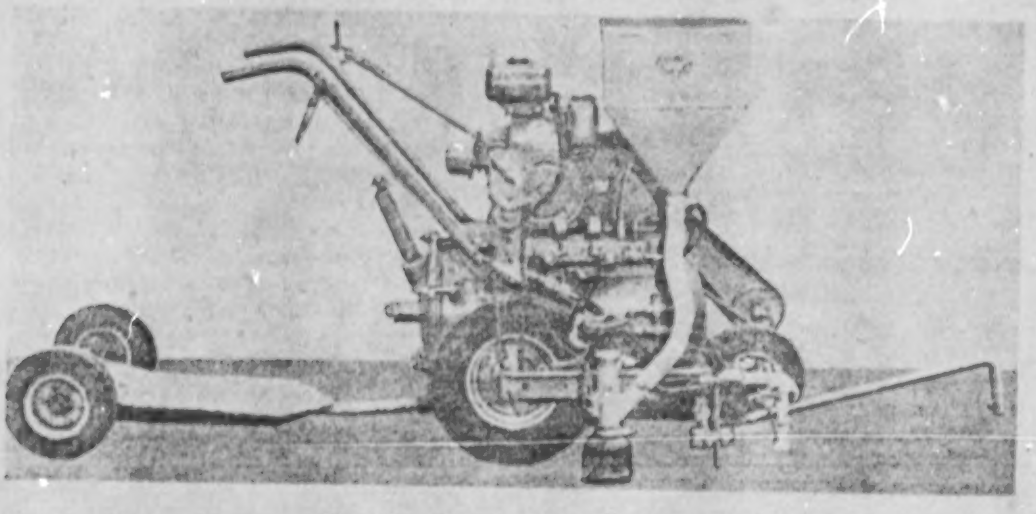

Figure 85. Power-operated traffic marker.

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before it is placed into any paint tank. Paint tank lids or covers are of the clamp-on type. Most of the paint tanks have a manual or power-operated agitator which keeps the paint thoroughly mixed during operation. This agitator is also used for cleaning the tank.

17-7. The paint guns mounted on a traffic marking machine are of the same design as those used for ordinary spray painting. The width of the spray is governed partly by the distance the spray gun nozzle is positioned from the surface being striped and by the spray gun adjustments.

17-8. Glass sphere dispenser hoppers vary in size, depending upon the size of the machine. The sphere dispensing mechanism is driven by an auxiliary shaft. After the glass spheres are metered (measured out) by the dispensing mechanism in the ratio of 6 pounds to every gallon of binder, they are blown into the wet stripe of binder by air pressure.

17-9. **Operating Characteristics.** Most traffic marking machines are designed to handle any standard traffic marking paint. They will also spray lacquers and reflectorized synthetic materials equally well. If it is necessary to thin traffic marking paint, always use the reducing agent recommended by the manufacturer; never use gasoline. Glass spheres are metered and applied by a special mechanism on the machine.

17-10. **Operator Maintenance.** The maintenance of power-operated traffic marker machines should be performed according to the directions set forth by the manufacturer. However, if such manuals are not available, the suggestions listed in the following paragraphs should be followed.

17-11. The preventive maintenance services for the gasoline engine are similar to those for any gasoline engine. The lubricating oil in the crankcase should be kept at the proper level. This oil should be changed at intervals of 25 to 50 operating hours. The oil filter cartridges should be renewed when the oil is changed. The air filter should be removed from the engine, disassembled, and washed in cleaning solvent. New lubricating oil should be placed in the air filter when it is installed.

17-12. To clean the paint tank, remove all the paint from it. After this is done remove the cover and pour about a gallon of thinner into the tank. Replace the cover and let the fluid agitate for 2 or 3 minutes, and drain. Again remove the cover from the tank and wipe it out with a clean cloth. This procedure helps to get most of the paint from the tank. Now replace the cover and pour enough thinner into the tank to cover the fluid outlet leading to the spray guns, and apply pressure to the paint tank. Open the controls and force the thinner through the fluid lines and spray guns. Then drain out what fluid is left in the paint tank and remove the cover. Wipe out the tank and clean all external units.

17-13. After each use, the paint guns should be removed, disassembled, and cleaned thoroughly. Here are a few of the things to check:

- The bead spreader, if it has any moving parts, should be lubricated frequently.
- Driving units, such as belts and chains, should be checked frequently for wear. Drive chains may be lubricated as required.
- Wheel bearings should be checked for adjustment and lubricated when necessary.
- Tires should be inflated to the proper pressures.

17-14. Grease fittings and oil cups are provided for greasing and oiling various units. The machine should be stored in a sheltered place when not in use.

17-15. **Glass Sphere Dispensing Gun.** Whenever glass spheres are to be embedded in traffic paint which has been applied with a paint brush or spray gun instead of a traffic marker, a glass sphere dispenser is used. This gun is actually an air pump. When it is filled with glass spheres and the handle is moved back and forth, the gun jets a uniform spray of spheres. For a light distribution, the gun is held so that the discharge chute is at the top, then as the gun is turned in a clockwise direction, the distribution of glass spheres increases. These glass spheres reflect light when applied to curbs, lane markings, and runways.

17-16. Another item used to mark traffic lanes that may easily be seen at night is laminated backed adhesive. This material is flexible and may be cut to form letters, numbers, etc. It comes in various colors.

18. Sign Making Equipment

18-1. Making signs is a very important part of your job. A protective coating specialist is called on very frequently to paint signs on

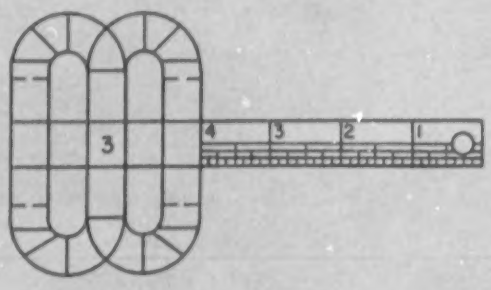

Figure 86. Stencil key set.

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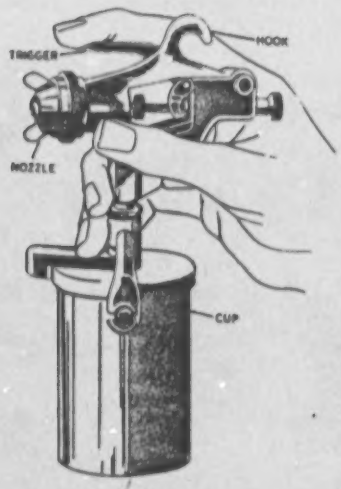

Figure 87. Stencil spray gun.

ground equipment, parking lots, driveways, buildings and almost everywhere imaginable.

18-2. There is a varied assortment of equipment available to assist you to do a professional job when you are called on to "make a sign."

18-3. **Stencil-Cutting Machines.** Stencil-cutting machines may vary in appearance and size. Regardless of the size (range from ¼- up to 4-inch cutters) the machine will have a handwheel to position an indicator to the letters, number, or mark to be cut, and a cutting handle to depress. The rotating handwheel portion of the stencil machine contains the punch, which is positioned under the cutter handle. Positioning the indicator brings the punch in alinement with a "die" in the lower portion of the machine. Depressing the cutting handle forces the "punch" into the "die," thus cutting the desired letter or number into the stencil board.

18-4. **Stencil Board.** The stencil board comes in two grades, a high wear resistance (grade 1) and a moderate wear resistance (grade 2). The grade 1 board is available in sheet size 8″ x 24″, 20″ x 32″, and 24″ x 36″. The grade 2 board comes only in one sheet size, 20″ x 24″. The grade of stencil board needed for a job is determined by whether the stencil will be used only once or several times.

18-5. **Stenciling Ink.** While any suitable paint may be used to stencil, there is a specific stencil ink that will mark porous surfaces, wood and cardboard shipping containers, burlap, and canvas. This ink comes in black, white, and yellow colors.

18-6. **Stencil Set (Brass).** When a stencil-cutting machine is not available for use, a professional job can be obtained with a brass stencil set. It is good practice to have two or three sets of each size on hand, as many signs contain two or three of the same letters and it will save time if the complete sign can be made at one time.

18-7. The stencil set consists of brass numbers and letters that interlock to form the desired words and numbers. The outfit includes a container and the following stencils: complete alphabet; figures 0 to 9 and one ampersand; one comma; one apostrophe; one period; one spacer; and four end pieces. The letters and numbers are gothic style and may be obtained in 1-, 1½-, 2-, 3-, and 4-inch sizes.

18-8. Immediately after use, these letters and numbers should be disassembled and washed with the same type of thinner used to thin the stencil paint.

18-9. **Stencil Key Set.** The stencil key set is used as a guide for layout and for drawing letters and numbers on stencil boards. A 3-inch stencil key set is shown in figure 86. To use the stencil key set, first mark off a horizontal line on the stencil board. Then use the key set to outline the desired numbers and letters, using either the inside or outside of the set. After all the letters/numbers have been outlined on the stencil board, simply cut them out with a sharp knife or razor blade.

18-10. **Spray Gun.** A spray gun, as shown in figure 87, is desirable for stenciling. This gun is smaller than the one used for painting, and is known as a touchup gun. It is not mandatory to have a small stenciling spray gun in a shop; however, it is desirable to have at least one spray gun that can be used only for this purpose. It is usually convenient to have more than one cup for a spray gun when more than one color of stencil paint is used. The extra cups facilitate spraying different colors of paint. General care and maintenance for a stenciling spray gun are the same as previously described for the regular paint gun.

18-11. **Layout tools.** Whether you are using the brass stencil or the board you prepared with the stencil key set, you must lay out (aline) the stencil in place. The tools that you need for this layout consist of a straightedge, yardstick, steel-square, and dividers. Using whatever tools you need, position the stencil and secure it in place with masking tape.

18-12. **Stencil Brushes.** On jobs where it would be impractical to use a spray gun, you

can use a stencil brush or roller. The most common brushes are the artist's stencil brush, stencil brush, and the fountain stencil brush.

18-13. *Artist's stencil brush.* This brush is round with black bristles in a long polished cedar handle. The bristles are held in place by a metal ferrule. The diameter at the ferrule is ½ inch and the bristle length is 1 inch.

18-14. *Stencil brush.* This brush is made of 100 percent hog bristles, with the flag ends cut. It has a long wooden handle and comes in either $^{13}/_{16}$" x $^{15}/_{16}$" or $1^{1}/_{16}$" x $1^{1}/_{16}$" sizes.

18-15. *Fountain stencil brush.* This is a brush with a reservoir handle. The leakproof reservoir holds a minimum of 2 ounces of stencil ink. The bristles extend 1½" beyond the metal ferrule. A shutoff valve is provided between the reservoir and the brush to adjust the flow of stencil ink as well as to shut it off completely.

18-16. A roller about 2 inches wide and 1½ inches in diameter is sometimes used to stencil. The roller is rolled over a small amount of paint spread on glass or a metal sheet; then rolled over the stencil to make the sign.

18-17. **Pressurized Spray Cans.** Another item used for stenciling small signs is the pressurized spray can. Spray cans are easy to use and come in various colors. The chief advantage of these cans is that there is no cleanup after you complete the job.

CHAPTER 4

Ladders, Scaffolds, and Hoisting Equipment

IT IS IMPORTANT for the protective coating specialist to know how to select and erect ladders and scaffolding to reach an area that cannot be reached from the ground. In the erection and use of ladders and scaffolding, safety is of prime importance. In the construction field, the number of serious accidents caused by scaffolds and ladders that are not erected or used properly far exceeds those from other sources. A scaffold or ladder that is not erected or used properly not only endangers the workers using the scaffold but could be a death trap for workers under it.

19. Ladders

19-1. Ladders are devices used to gain access to higher levels where work is to be done. It is possible to paint the entire exterior surface of a one- or two-story building from a ladder; however, it is often more comfortable and time-saving if scaffolding is erected.

19-2. Ladders are of several types—single-rung, extension, step, and trestle ladders. Each ladder is designed for a specific use and should not be used for any other purpose. Ladders are made of magnesium, aluminum, steel, or well seasoned wood, free of knots or other defects.

19-3. **Single-Rung Ladders.** A single-rung ladder consists of two side rails from 8 to 30 feet in length with rungs (steps) each 12 inches, capable of supporting weights up to 500 pounds. The size of a ladder is determined by its overall length. Figure 88 shows a typical single-rung wooden ladder. It should be equipped with safety shoes or spikes as shown in figure 89. These shoes help to keep the bottom of the ladder from slipping.

19-4. The selection of a ladder depends upon the height at which the painter must work. A painter works most efficiently in a space not higher than his breast nor lower than his knees; therefore, the length of a ladder is critical because the area that can be reached is limited. A ladder should be long enough so that a painter can reach his work without climbing past the third rung from the top.

19-5. A ladder is raised by placing the base against the foundation of the building, raising the top end, and walking under the ladder toward the building. As soon as the ladder is perpendicular, the bottom is pulled out from the building to a distance of ¼ of its length as shown in figure 90. If it is necessary to get on top of a building, the ladder must extend above the eave at least 30 inches.

19-6. Two ladders can be adapted to hold a scaffold board or extension plank by the use of two steel ladder jacks as shown in figure 91. These jacks can be used in front of or behind the ladder. If they are placed between the ladder and the building, it will allow you to be closer to the wall for painting.

19-7. An extension plank as shown in figure 92 is made of material that is well seasoned, straight grained, and free of any knots or defects. This board is constructed so that it can be adjusted in length. It is available in various sizes. A scaffold board of lumber that is straight grain, free of knots or any other defect can be used in lieu of the extension plank. The size of the lumber depends on the span of the scaffold, for instance:

Size of Plank (inches)	*Permissible Span*
2 x 8	8′
2 x 10	10′
2 x 12	12′
2 x 14	14′
2 x 16	16′
2 x 20	20′
3 x 10	20′

19-8. **Extension Ladders.** Extension ladders as shown in figure 93 consist of two or more sections which can be adjusted to various lengths by pulling on the rope which is reeved (threaded) through the pulley. Although single straight lad-

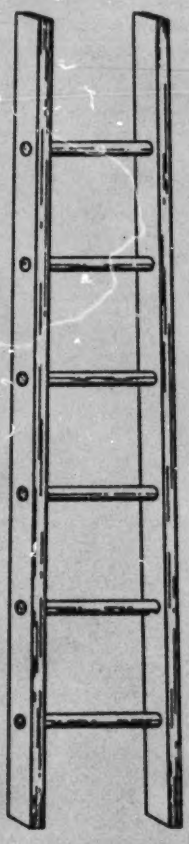

Figure 88. A single-single ladder.

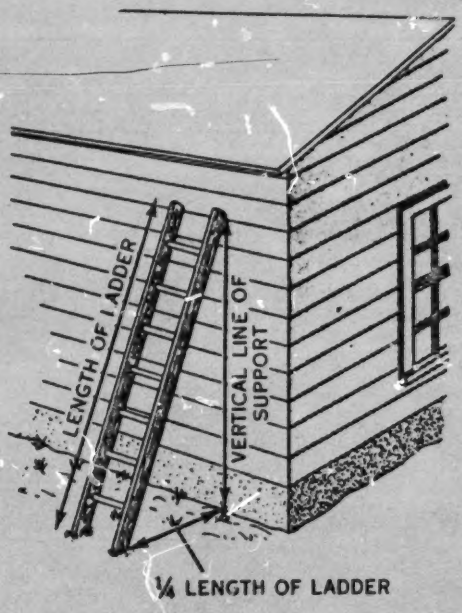

Figure 90. A properly placed ladder.

ders are available up to 30 feet, it is better to avoid single ladders of over 20 feet because of the difficulty of raising them.

19-9. Extension ladders overlap to hold the sections together. The sections will overlap at lease 3 feet for a ladder up to 38 feet, 4 feet up to 45 feet, and 5 feet for any extension over 45 feet. A positive locking device is provided so that one ladder may be locked to the rungs of the other.

19-10. Extension ladders are erected in the same manner as straight ladders with the sections in a down position. After the ladder is erected, the top can be leaned away from the building and raised to the desired height with the pulley and rope arrangement.

19-11. **Stepladders.** A stepladder, as shown in figure 94, is used on flat surfaces where a sound footing can be obtained. Stepladders are available in lengths up to 20 feet. When erecting a stepladder, be sure that the brace is extended and locked.

19-12. **Trestle ladders.** Trestle ladders consist of two single ladders hinged at the top to form an "A" shaped device. When two of these ladders are erected with a plank or extension platform extending between the rungs of the two ladders, the combination forms a painter's trestle as shown in figure 95.

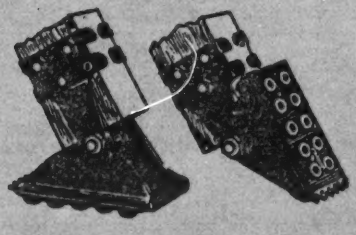

Figure 89. Ladder safety shoes.

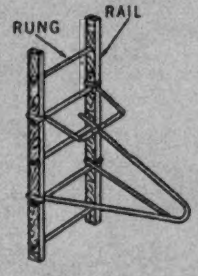

Figure 91. Ladder jack.

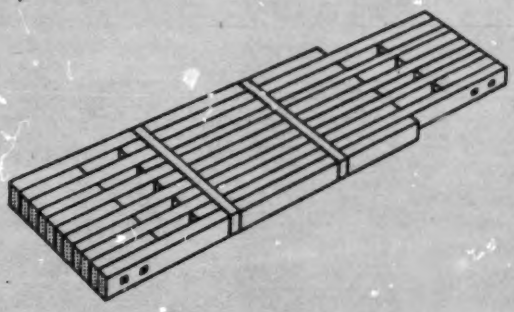

Figure 92. Extension plank jack.

19-13. Ladders must be kept clean and free from dirt and paint. Wood ladders should be shellacked or varnished or given two coats of linseed oil as a protective coating against the weather. Paint is not used on wooden ladders because it would hide any obvious defects. Locking devices on stepladders and extension ladders should be checked for positive action before each use.

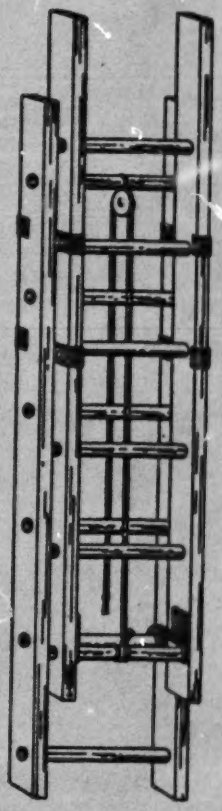

Figure 93. Extension ladder.

Figure 94. A stepladder.

19-14. When ladders are not in use, they should be stored in a sheltered, well-ventilated place away from weather elements. They should be hung on brackets by the side rails to prevent warping.

19-15. Additional safety precautions that you must observe when using a ladder are:

- Under no circumstances use stepladders as substitutes for workstands.
- When ascending or descending a ladder, face the ladder and hold on to each side rail.
- When the security of a ladder is endangered by other activities, rope off the area around it, fasten it securely, and assign a man to steady the bottom.
- When you use a ladder in front of doors which open toward it, block off the doors and route personnel to another exit.
- Never leave a ladder unattended for any length of time while it is erected—take it down and lay it on the ground.
- When working on a ladder stand no higher than the third rung from the top and do not attempt to reach beyond a normal arm's length.
- If you need help to do the work, have your helper get another ladder—don't allow anyone on the ladder with you.

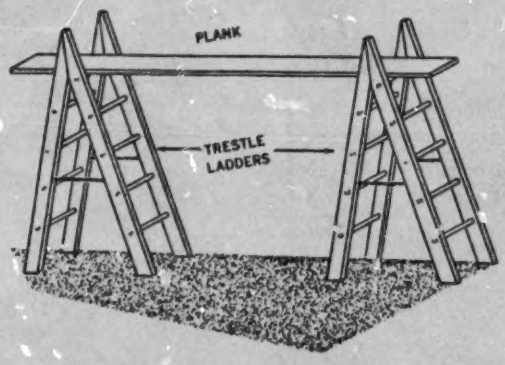

Figure 95. A painter's trestle.

- If there is any danger of the ladder slipping, tie it to something solid with a rope. Equipping a ladder with safety shoes does not always keep a ladder from slipping.
- Never place a ladder on a movable object.
- Never climb a ladder while using both hands to hold material; at least one hand must be used while climbing or descending a ladder.
- Never place either the top or the bottom of a ladder against unstable material.

20. Scaffolds

20-1. A scaffold is a temporary elevated platform to support workmen and tools. It may range from individual planks placed across structural members of a building to steel mobile work platforms. A well constructed or erected scaffold is safer to work from than a ladder. Types of scaffolds most commonly used by painters include the scaffold horse, half horse (lean-to), independent metal scaffold, swing stage, and boatswain chair.

20-2. **Scaffold Horse.** A scaffold horse as shown in figure 96 is a very convenient item to use if you wish to construct a simple scaffold. These horses are normally used in pairs; however, a stairway, porch, or any other stationary object can be used to hold one end of a work platform while a scaffold horse holds the other. Check the nailing of the legs and braces before each use.

20-3. **Independent Metal Scaffold.** Double-pole built-up scaffold (metal or wood) is completely independent of the main structure. Several types of patent independent metal scaffolding are available for simple and rapid erection. The scaffold uprights are braced with diagonal members and the working level is covered with a platform of planks as shown in figure 97. All bracing must form triangles, and the base of each column requires adequate footing plates, as shown in figure 98, for the bearing area on the ground. If the ground is fairly even, the footing plates can be secured to a 2 x 8 placed on the ground.

20-4. The patented steel scaffolding is usually erected by placing the two uprights on the footing plates and inserting the diagonal braces. The diagonal braces have end fittings which permit rapid locking in position, as shown in figure 99. A second tier is placed on the first tier, with the bottom of each upright locked to the top of the lower tier. A third and fourth upright can be placed on the ground level and locked to the first set with diagonal bracing. The scaffolding can be built as high as desired, but high scaffolding should be tied in to the main structure, as shown in figure 100.

20-5. Side brackets, as shown in figure 101, are clamped on the scaffold uprights (scaffold leg) to provide platforms at various height levels.

20-6. If the scaffold is to be used on a solid floor and frequent moving is necessary, a rolling tower can be constructed of the same scaffold sections by replacing the footing plates with locking casters. The height of the tower must not exceed four times the smallest base dimensions, and it must have a guardrail above the working platform.

20-7. **Swing stage scaffold.** A swing stage scaffold, as shown in figure 102, is used to reach the upper surfaces of the exterior wall of a building by suspending a platform from the roof or cornice with ropes or steel cables. A swing stage scaffold consists of two cornice hooks, two swing stage stirrups, guardrail, scaffold platform, toe board, and two sets of blocks and tackle

20-8. *Cornice hooks.* Cornice hooks are large metal hooks which hook securely over the top of a substantial portion of a roof or cornice. The top of each hook is provided with an eye to which tieback ropes are fastened. The other end of the tieback rope must be fastened to the base of a chimney, soil pipe, or any other securely attached projection which would support the weight of the scaffold and load to be placed on it.

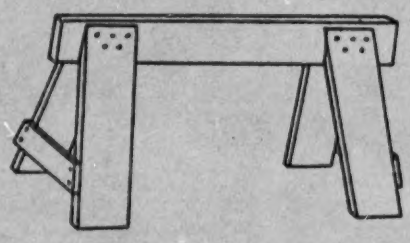

Figure 96. Scaffold horse.

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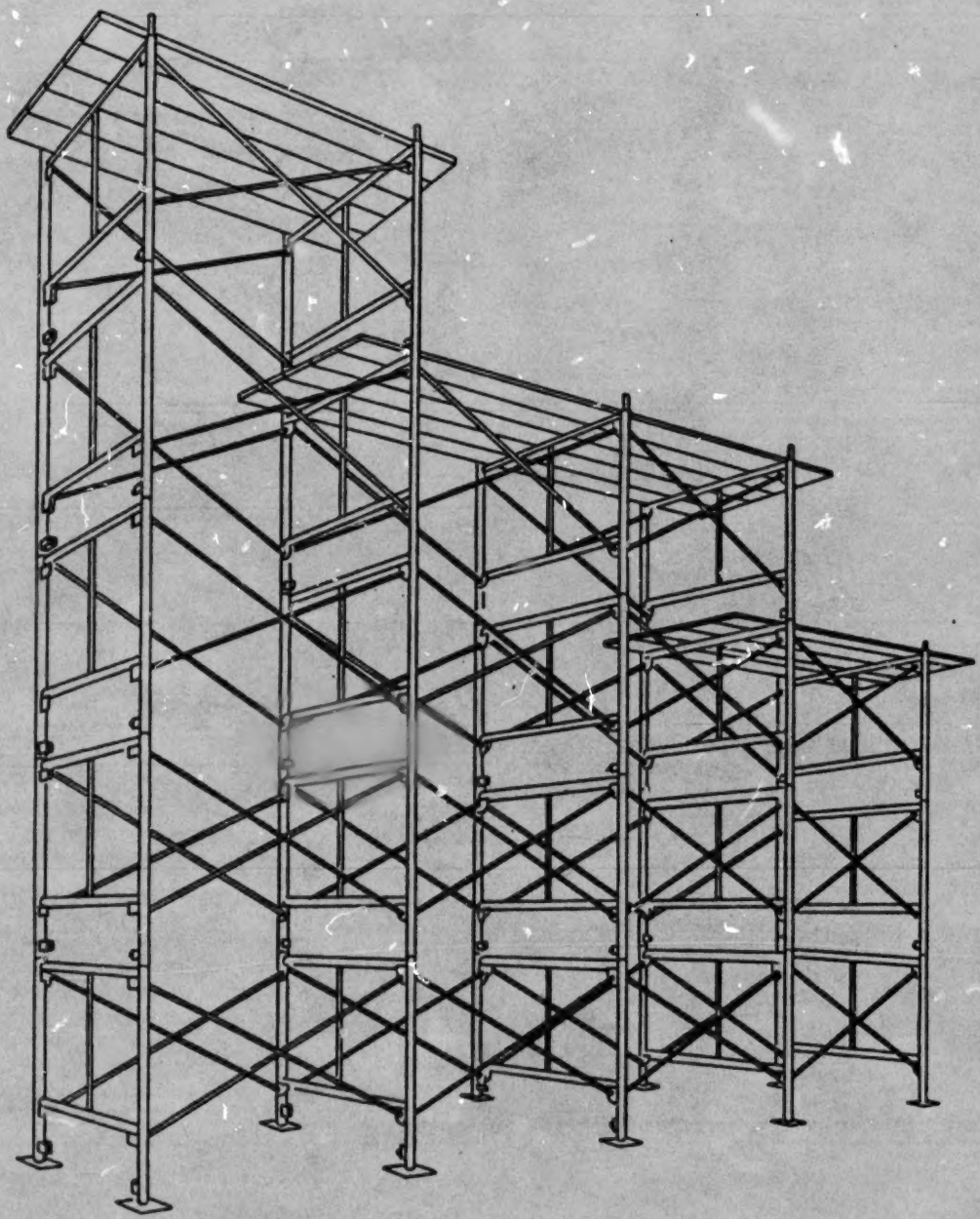

Figure 97. Independent metal scaffold.

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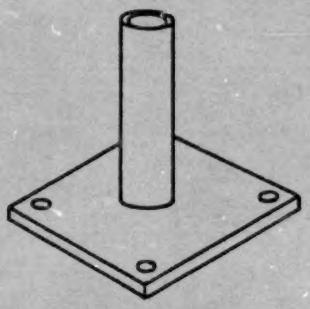


Figure 98. Base plate.

These tieback ropes are for safety. The lower ends of the hooks are also equipped with an eye into which the blocks are attached.

20-9. *Swing stage stirrup.* A swing stage stirrup is the metal unit which supports the scaffold platform. Two stirrups are required for a scaffold. A ring is located at the top of each stirrup to attach a set of blocks and tackle. Rollers are provided so that the scaffold will not hit the wall.

20-10. *Guardrail.* A guardrail of 2 x 4 material is a part of the scaffold. The guardrail helps protect a worker from falling from the platform.

20-11. *Scaffold platform.* A scaffold platform is the working space on which you move about as you work. It should be not less than 20 nor more than 24 inches in width, and not more than 26 feet in length. Well seasoned 2-inch lumber that is straight and free of knots or other defects is used for the platform.

20-12. *Toeboards.* Toeboards constructed of 2- x 4-inch material are located at the front and back of the scaffold to prevent material from slipping or accidentally being knocked off. They run the full length of the scaffold.

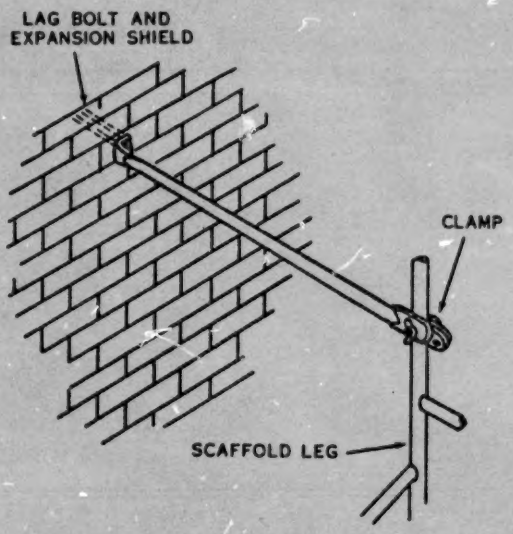


Figure 100. Building tie in.

20-13. *Blocks and tackle.* Blocks and tackle of a special type are used on each end of the swing stage scaffold to raise and lower the unit as required. A hoisting machine may be substituted for the blocks and tackle.

20-14. There are many safety rules that you must practice while using swing stage scaffolds.

a. After erecting and before using a swing stage scaffold, hoist it 1 foot off the ground and test it with four times the working load.

b. Lash the swing stage to the building or structure wall as soon as possible after hoisting to keep it from swinging outward

c. No more than two painters should work on a swing stage at one time. Each painter should be provided with a safety belt which should be

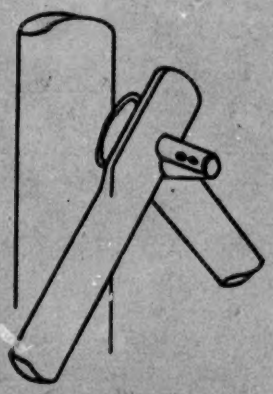


Figure 99. Quick lock.

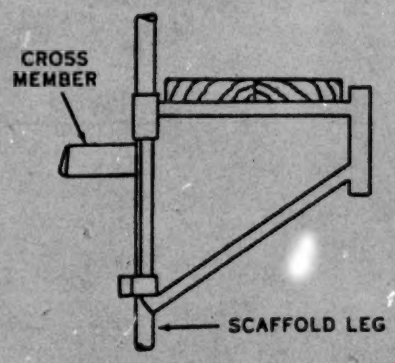
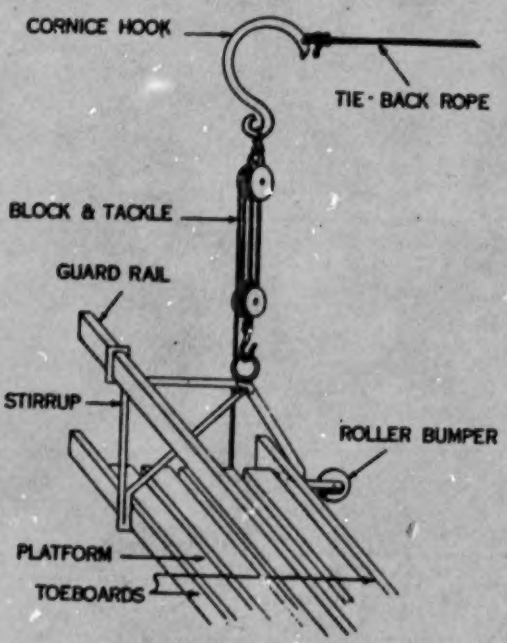


Figure 101. Side bracket.

attached to an individual lifeline. The line should be fastened above, free from the stage.

d. All fiber ropes exposed to acids or acid solutions should be replaced immediately. Whenever possible, use steel cable for hoisting equipment when you work with acid solutions.

e. Swing stage scaffolds not in use should be lowered to the ground for safety reasons.



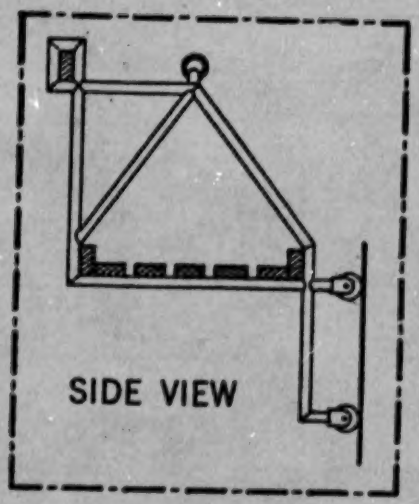


Figure 102. Swing stage scaffold.

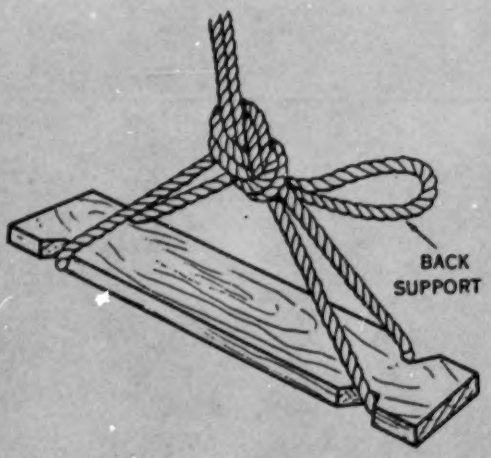


Figure 103. Boatswain's chair.

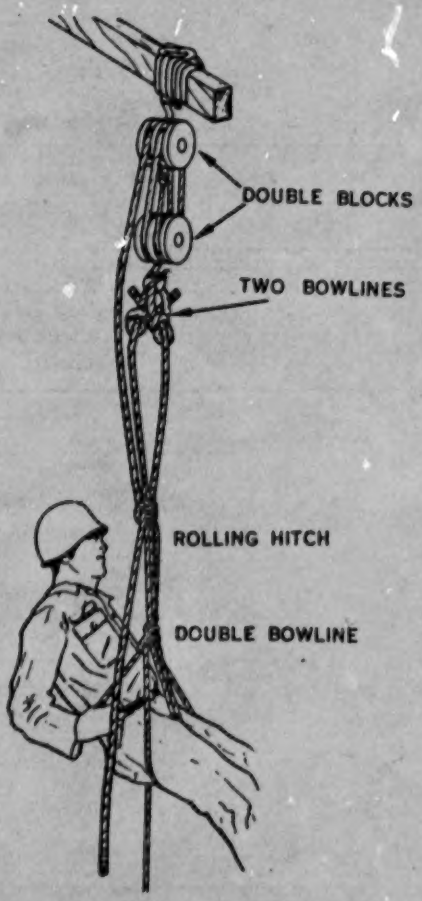


Figure 104. Boatswain's chair with tackle.

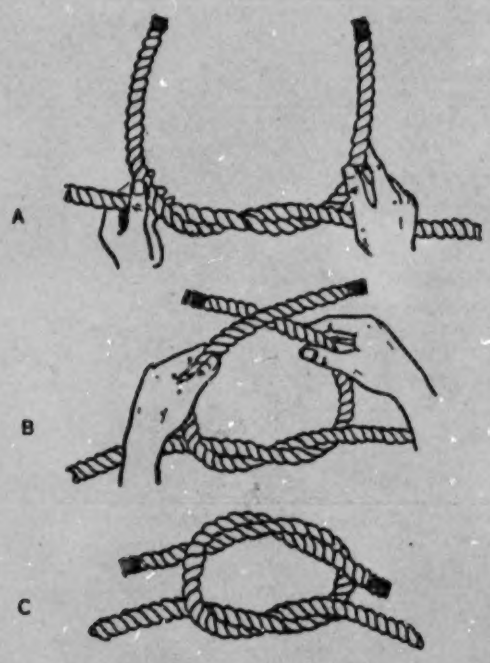


Figure 105. The square knot.

f. When you raise a swing stage scaffold, keep the weight on the outside of the platform until the swing stage is secured to the building.

g. Make it a rule never to touch the wall next to a swing stage until it is secured to the building. A light push against the wall may swing the stage out in such a way that you may lose your balance and fall.

h. Check the operation of the hoisting machine every time it is to be used.

i. Inspect each tackle block assembly every time it is to be used.

j. Lubricate tackle block pulley wheels as necessary.

k. Tackle block ropes must be kept under cover to guard against deterioration by weather.

l. Tackle block ropes deteriorate and become unsafe when exposed to acids.

m. Tackle block ropes should not be permitted to scrape against sharp projections such as scaffolds, window sills, beams, or the walls of buildings.

n. Ropes under heavy loads must not be pinched between hard surfaces.

o. Wear on rope increases when it runs through sheaves which are too small.

p. Ropes should be lubricated with beef tallow as required.

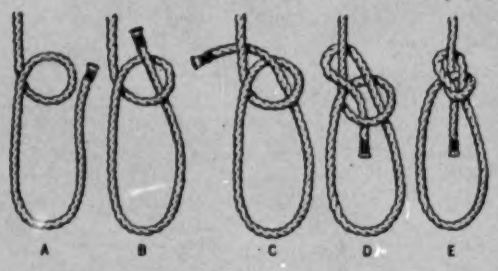


Figure 106. The bowline.

q. Ropes must not be allowed to slip over pulley wheels that do not turn.

r. Cornice hooks must be inspected for cracks and bends which result from strains.

s. Inspect all planks that are used as a part of a swing stage scaffold.

t. Inspect all swing stage stirrups prior to each time they are to be used.

u. Never walk under a swing stage scaffold.

v. Never reeve a set of blocks on the ground where dirt, dust, or mud will get on the ropes.

w. Never use a swing stage scaffold without a guardrail.

20-15. All the units that form a part of a swing stage or the units that are used in conjunction with it should be inspected each time before they are used. The wooden platforms, guardrails, and toeboards, as well as metal stirrups and hooks, should be inspected for worn parts. The steel cables should be inspected for broken wires, corrosion, wear, and kinks. Fiber rope inspection should reveal any broken, cut, or weakened strands.

20-16. Swing staging should be stored in a dry place to prevent the warping and splintering of wooden sections; the rusting of wire cable, tackle blocks, and hoisting machines; and the rotting of fiber ropes.

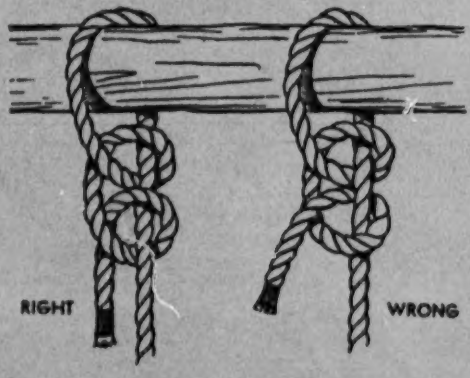


Figure 107. Two half-hitches.

20-17. **Boatswain's Chair.** A boatswain chair as shown in figure 103 is made to support one man. It is used to paint small areas that cannot be reached by ladders or where it is impractical to erect a scaffold. It is made up using a double bowline knot. If the chair is to support a man for just a short period of time, the notched board can be eliminated and the worker can insert his legs through the loops.

20-18. The boatswain's chair is supported by securing blocks and tackle to the roof, ceiling joists, or rafters. Make certain that they are secure. One man can raise or lower himself or can be assisted from the ground. When working alone, the fall (control) line is attached to the suspending tackle with a rolling hitch, as shown in figure 104. This allows the worker to lower himself. When the worker is assisted from the ground, the fall line must be tied to a tree or building member that will hold the weight of the worker.

21. Hoisting Equipment

21-1. The protective coating specialist must know how to tie simple knots, use blocks and tackle and hoisting equipment efficiently and safely.

21-2. **Knots.** Knots are used in many ways to tie equipment, materials, scaffolds, and many other items to blocks and tackle so that they can be raised or lowered as needed. Some of the most commonly used are the square knot, bowline, half-hitch, double bowline, and rolling hitch.

21-3. *Square knot.* The square knot is used for tying two ropes of the same size together. It will not slip and is easy to untie. To tie this knot, lay the running ends of both ropes together but pointing in opposite directions. Pass the running end of one rope under the standing part of the other. Bring the two running ends up away from the point where they cross, as shown at A in figure 105. Cross them again, as shown at B. Pass one running end under the other so that each is parallel to its own standing part, shown in C, and pull them tight. You have a square knot.

21-4. *Bowline.* The bowline is used to form a loop in the end of a rope that will not slip and is easily untied. To tie the bowline, make a loop in the standing part of the rope, as shown in A in figure 106. Pass the running end through the loop from underneath, shown at B; up and around the standing part of the rope, shown at C; and back through the loop from the top down, shown at D. The running end passes down

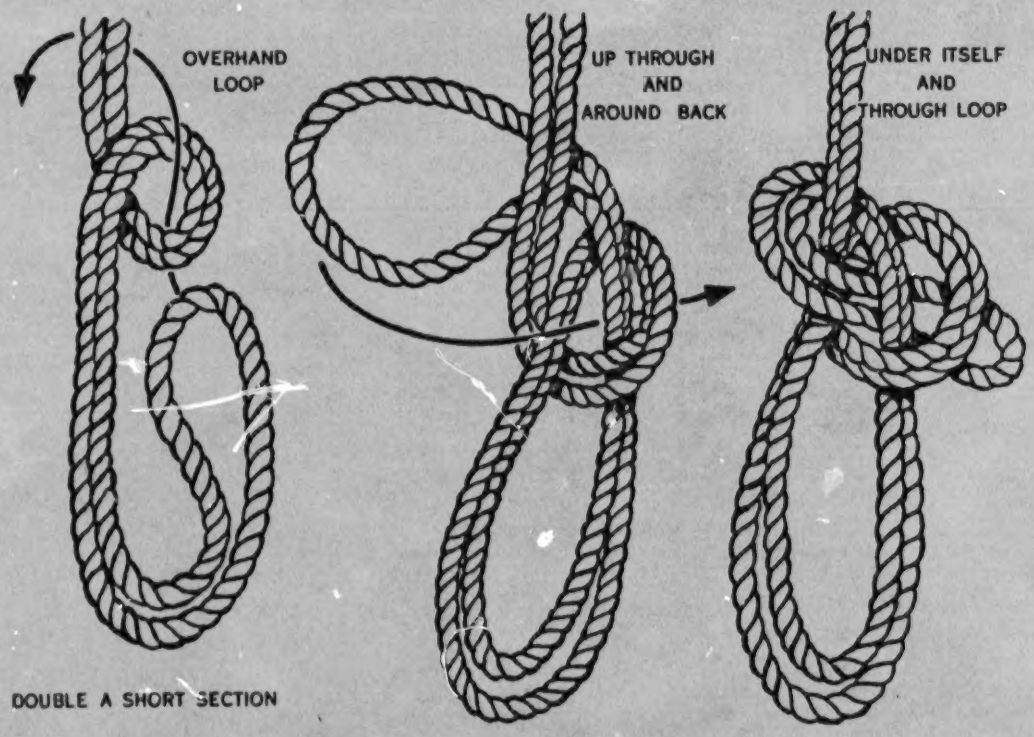


Figure 108. Double bowline.

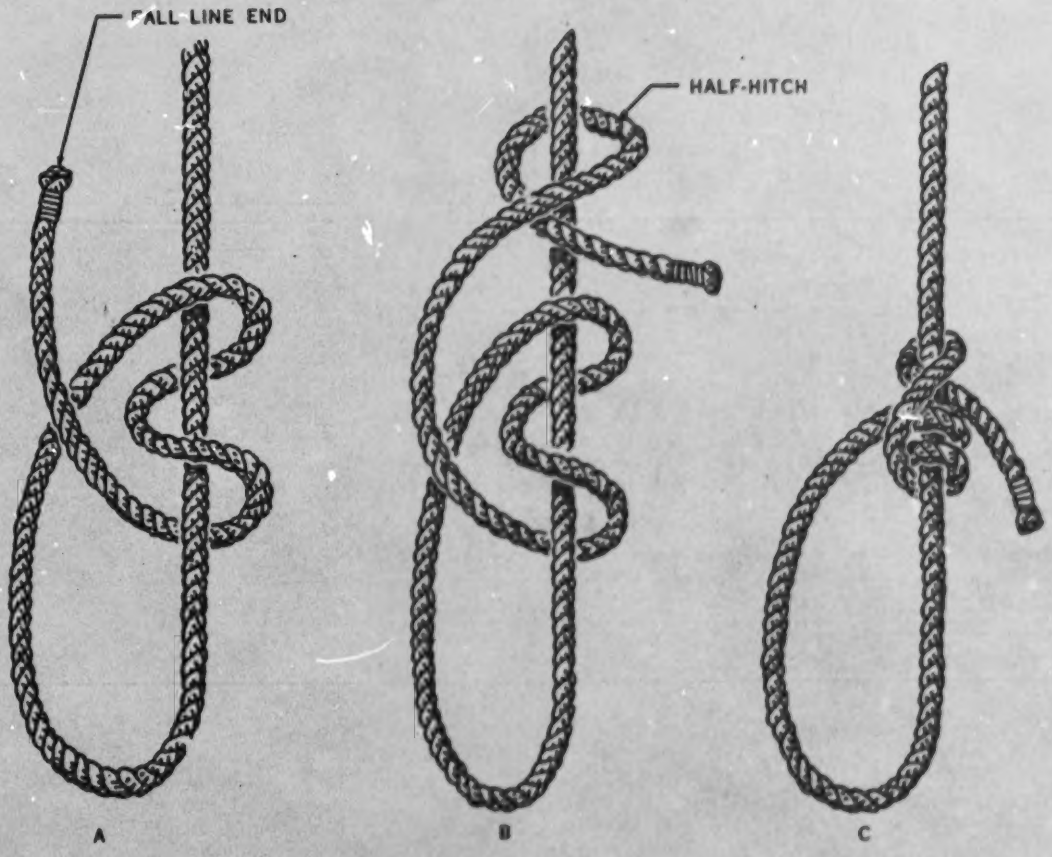


Figure 109. Rolling hitch.

112

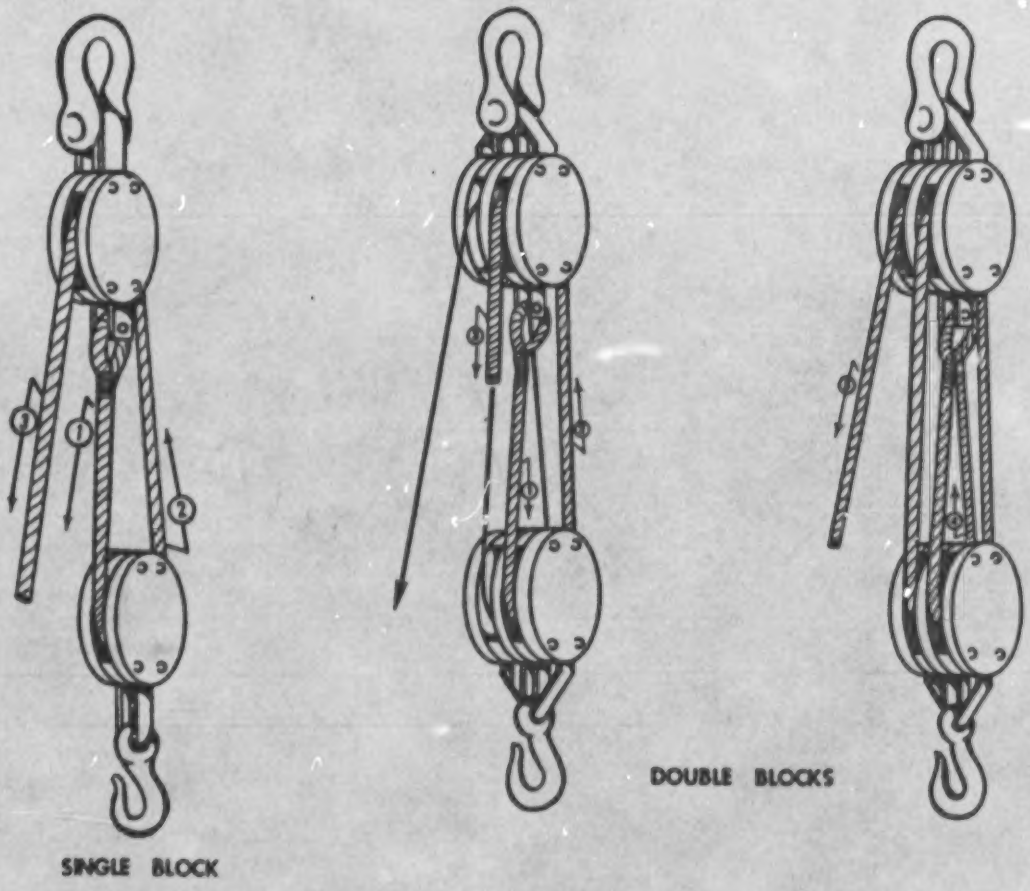


Figure 110. Reeving single and double blocks.

120

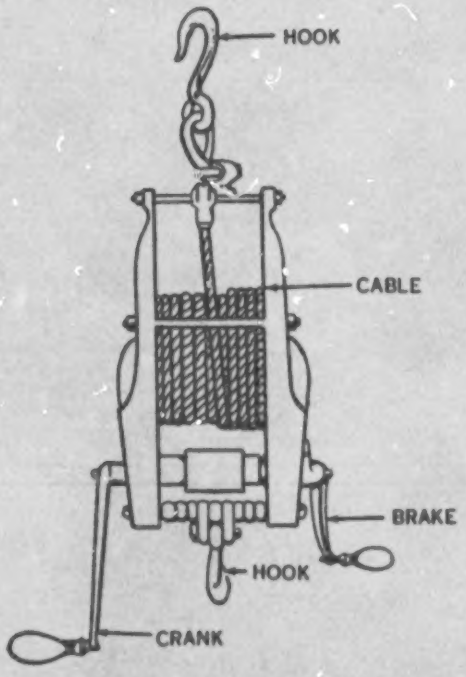


Figure 111. Hoisting machine.

through the loop parallel to the rope coming up through the loop. Pull the rope tight and you should have a bowline as shown at E.

21-5. *Two half-hitches.* A quick way of tying a rope to a timber is by the use of two half-hitches, as shown in figure 107. To tie this hitch, pass the running end of the rope around the timber and take a turn around the standing part and under the running end. This is one-half hitch. Pass the running end around the standing part of the rope and back under itself again and you will have two half-hitches.

21-6. *Double bowline.* The double bowline is made as shown in figure 108. It forms three nonslipping loops. This knot is used for making the boatswain's chair that we discussed in the previous section of this chapter

21-7. *Rolling hitch.* The rolling hitch is used to lower a load slowly. An important use of this knot for the protective coating specialist is with the boatswain's chair. The workman can lower himself by releasing the pull on the fall line and rolling the knot. How to tie this knot is illustrated in figure 109.

21-8. Repeated tying of knots causes rope to wear rapidly. It should be inspected frequently to insure safety. Check rope visually for abrasions, broken fibers, cuts, fraying, and deterioration from acids or corrosive substances. Remove from service any rope found to be defective. When not in use, store rope in a dry, well-ventilated place.

21-9. **Blocks and Tackle.** Blocks and tackle, also referred to as falls, are one type of hoisting equipment used to raise and lower the platform of a swing stage scaffold. A set of falls can be made in various combinations of single and double blocks or even triple blocks or more. The number of sheaves (pulleys) designates the size of the block. As the number of sheaves is increased, the mechanical advantage is increased.

21-10. To reeve a set of blocks, lay the blocks out on a level surface other than the ground to avoid getting dirt into the operating parts of the blocks. To reeve single and double blocks, refer to figure 110 and thread the rope through the sheaves as shown.

21-11. When the reeving is completed, the blocks are ready to be fastened. One block is connected securely to the load, the other is connected to a substantial anchor. To move the load, pull on the fall line (loose end of the rope).

21-12. When you use blocks and tackle for swing staging, the rope must be first grade Manila of at least ¾-inch diameter.

21-13. **Hoisting Machine.** Another item that you may be using while painting in elevated places is the hoisting machine, shown in figure 111. This machine uses steel cable instead of rope. Hoisting machines of this type possess a lock and brake which are controlled by the painter. Before leaving this machine, you should remove the control handle and lock the brake. All rope and cable used in supporting scaffolds must be inspected daily.

114

CHAPTER 5

Metal Identification and Corrosion

CORROSION OF METALS is a constant enemy of the military, causing extensive damage to towers, pipelines, trucks, aircraft, and almost any other item that is made of metal. Corrosion quietly eats away the understructure or heart of a system. The problem is never ending. In this chapter, we will identify corrosion, find out what causes it, and discuss how to control it on various types of metal.

22. Types of Corrosion

22-1. Since corrosion of metals results in such tremendous loss of materials, time, and money, just what is corrosion? As to definitions, let's consider four different ones.

a. An engineer from the Electro-Chemical Society of New York stated that: "Corrosion is the destruction of a metal by chemical or electrochemical reaction with its environment."

b. A reservoir engineer says: "Corrosion is a process of nature designed to increase the horizontal permeability of the ocean."

c. *Encyclopedia Britannica* offers this definition: "Corrosion may be used to denote a chemical change through which metal passes from elementary to the combined condition."

d. *Webster's Third New International Dictionary*, 1963 edition, states: "Corrosion is a process of being worn away, as metals by rust or morals by decay."

22-2. Though the definitions vary, they all boil down to the fact that corrosion is a natural act of the metal trying to return to its lowest level of energy. In the case of a metal structure, the iron and steel try to return to their natural state, iron oxide (iron ore). The so-called noble metals, such as gold and platinum, do not corrode since they are chemically uncombined in their natural state. You, as a protective coating specialist, are concerned with the chemical changes that occur when metal is exposed to the elements.

22-3 The most common theory of corrosion is called electrochemical. The electrochemical theory of corrosion is best explained by the action that takes place in a battery cell. A galvanic battery cell is produced by placing two dissimilar metals in a suitable electrolyte, as shown in figure 112. The resulting electrochemical reaction develops a potential difference between these metals, causing one metal to be anodic and the other metal to be cathodic. In a dry cell, the zinc can is the anode and the carbon rod the cathode. Now, when an external electrical circuit is completed, current flows from the zinc case into the electrolyte, taking with it particles of zinc. This is an example of galvanic corrosion of the zinc case.

22-4. Four conditions must exist before electrochemical corrosion can take place:

(1) There must be something that corrodes (the metal anode).

(2) There must be a cause (cathode).

(3) There must be a continuous liquid path (electrolyte, usually condensate and salt or other contaminants).

(4) There must be a conductor to carry the flow of electrons from the anode to the cathode. This conductor is usually in the form of metal-to-metal contact, such as rivets, bolts, and welds.

22-5. The four conditions that are required before electrochemical corrosion can proceed are illustrated in figure 113. The elimination of any of the four conditions will automatically stop corrosion; e.g., an organic film on the surface of the metal will prevent the electrolyte from connecting the cathode and anode, and the current cannot flow; therefore, no corrosion occurs. This is illustrated in figure 114.

22-6. Because some metals are more subject to corrosive action than others, the possibility of a corrosion problem and the necessary control measures vary accordingly. Corrosive attacks begin on the surface of metal exposed to corrosive environment. If allowed to progress, corrosion

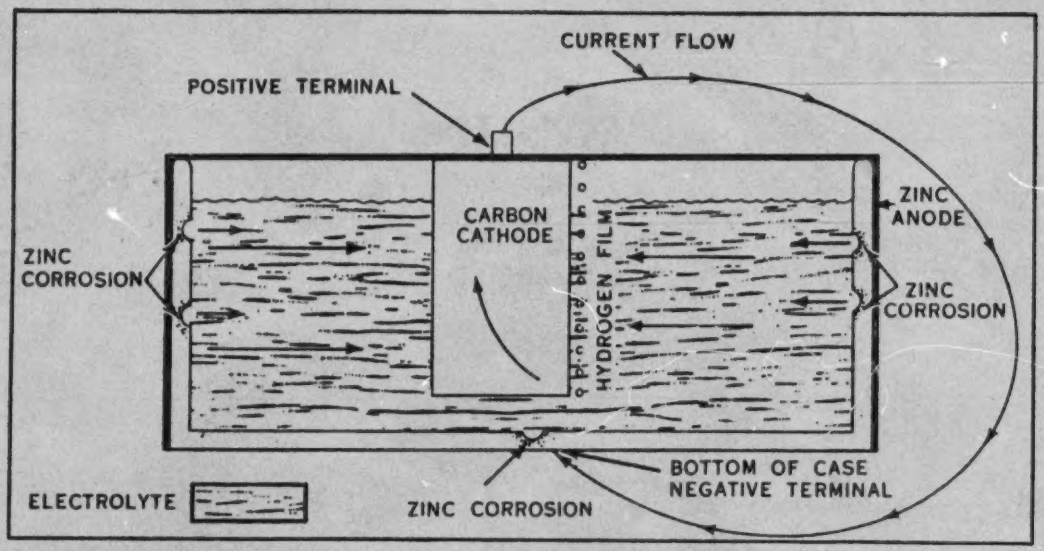


Figure 112. Theory of corrosion-battery cell.

works down into the core of the material, as shown in figure 115. Since corrosion never originates in the core, there will always be evidence on the surface when an attack is in progress as shown in figure 116.

22-7. Before you can identify corrosion, you must know what corrosion looks like on a metal surface. Corrosion takes place in various forms, depending on the type of metal, environment, and mechanical conditions. Among the many types of corrosion are uniform, galvanic, pitting, stress, intergranular, exfoliation, and concentration cells.

22-8. **Uniform Corrosion.** This is the most common form of corrosion. It is a general attack on the metallic surface. The surface effect produced by most direct chemical attacks is a uniform etching of the metal. On a polished surface this type of corrosion is first seen as a general dulling of the surface. If such corrosion is allowed to continue, the surface becomes rough and possibly frosted in appearance.

22-9. **Galvanic Corrosion.** This is a complete class of corrosion involving electrochemical action between two metals or between different areas of the same metal having different heat treatments or other metallurgical differences. Galvanic corrosion occurs when dissimilar metals are in contact and an external circuit is provided by the presence of moisture. It is usually recognizable by the presence of a buildup of corrosion at the joint between the metals. For example, aluminum and magnesium skins riveted together in an aircraft wing form a galvanic couple if moisture and contamination are present.

22-10. When aluminum pieces are attached with steel fasteners or screws, galvanic corrosion (see figure 117) can occur between the aluminum and the steel. The metals grouped together in figure 118 have no strong tendency to produce galvanic corrosion and are relatively safe to use in contact with each other. The coupling of

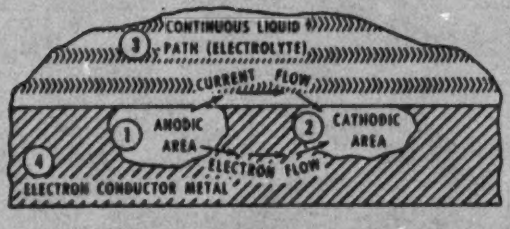


Figure 113. Conditions of electrochemical corrosion.

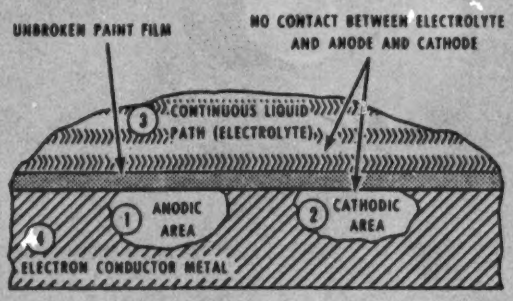


Figure 114. Prevention of corrosion by organic film.

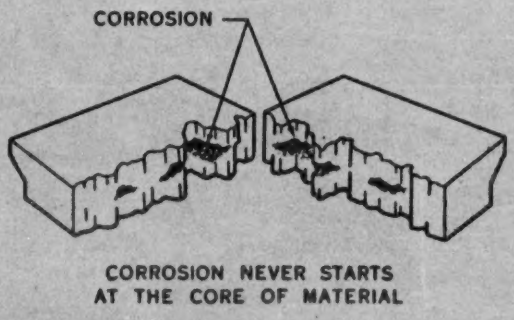


Figure 115. Core corrosion.

metals from different groups and distant from each other in figure 118 will usually result in galvanic or accelerated corrosion of the metal higher on the list. The farther apart the metals are in figure 119 the greater will be the galvanic tendency. This can be determined by measuring the electrical potential difference between any two metals.

22-11. **Pitting Corrosion.** Pitting corrosion may occur in most alloys, but it is most common in aluminum and magnesium. It is first noticeable as a white or gray powdery deposit, similar to dust, which blotches the surface. When the deposit is cleaned away, tiny pits or holes can be seen in the surface. This type of corrosion is a localized form that begins at a break in the passive (protective) film. Once broken a cell is formed between the exposed metal and the passive metal. Such breakdowns in the protective coating can occur at a rough spot, machining mark, scratch, or other surface flaw. Pitting corrosion can also occur under a small deposit (weld spot or dirt particle) which prevents the access of oxygen to the metal. Pitting corrosion proceeds at a rapid rate if the products of corrosion are conductive.

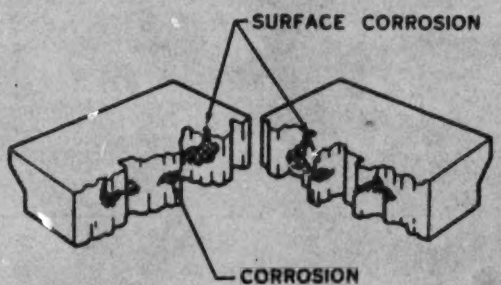


Figure 116. Point of entry-core corrosion.

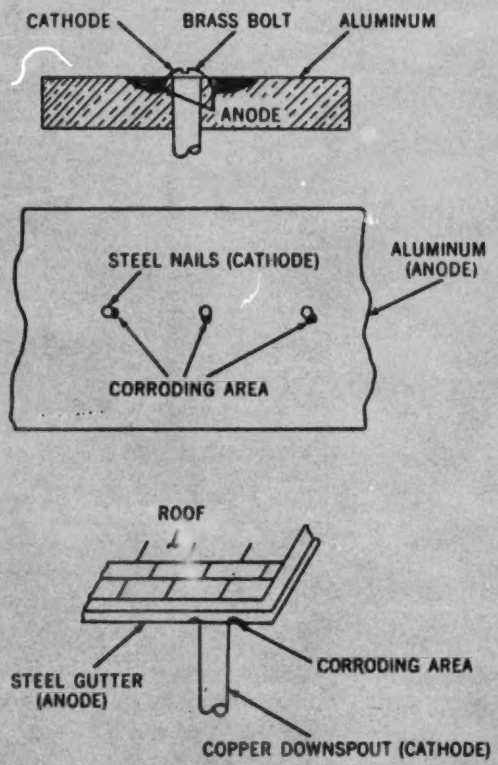


Figure 117. Galvanic corrosion-aluminum to steel.

22-12. **Stress Corrosion.** This type of corrosion is caused by the distortion of the granular structure of the metal. Such distortion may be induced by the metal's being punched, cold riveted, shrink fitted, or otherwise distorted after hot finishing. The distortion may also be caused by a bending or twisting of the metal. This bending or twisting condition may be a continuous stress or it may be an alternating stressed and unstressed condition.

22-13. Stress corrosion is due primarily to the fracture of the metal's surface film or coating. The fracture or tiny cracks permit the entry of moisture which results in an acceleration of the corrosion process.

22-14. After surface cleaning, stress corrosion cracks are usually visible at the bottom of corrosion pits. These corrosion pits may be formed prior to any stress condition, or they may form simultaneously with the stress, in which case the pitting rate is more rapid. In the second stage, the stress crack at the base of the pit develops rapidly and gradually penetrates the section until a fracture occurs.

GROUPING OF METALS AND ALLOYS

Group I	Magnesium and its alloys.
Group II	Cadmium, Zinc, and Aluminum and their alloys (including the aluminum alloys in Group I).
Group III	Iron, Lead, and Tin and their alloys (except stainless steel).
Group IV	Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, and Rhodium and their alloys; Stainless Steel and Graphite.

1. Metals classified in the same group are considered similar to one another.

2. Metals classified in different groups are considered dissimilar to one another.

Figure 118. Comparative groupings of metals and alloys.

22-15. A good example of stress corrosion is the use of cold-worked rivets to join steel sheets used in storage tank construction. The rivets carry an internal strain, the deformation of the rivet shank, which makes them anodic to the steel. The stressed area forms the anode to the adjacent unstressed parts. Since the rivets were also very small in area compared with the steel, they become badly corroded in comparison with the action on the steel.

22-16. **Intergranular Corrosion.** This type of corrosion is the reuslt of the metallic grain boundaries and the grain particle creating a cell in a corrosive solution or atmosphere. Intergranular corrosion is an attack on the basic grain structure of the metal. A highly magnified cross section of metal shows that its composition is made up of a number of tiny crystals or grains. Each of these tiny grains has a clearly defined boundary and each differs chemically from the one in the center of the metal. The adjacent grains of different elements react with each other as anodes and cathodes when they are in contact with an electrolyte. The early stages of this type of corrosion cannot be detected by normal visual inspections.

22-17. Some of the stainless steels are prone to intergranular corrosion if they are heated. This could occur during welding. The heating causes chromium carbides to collect at the grain boundaries, and the corrsion begins.

22-18. **Exfoliation Corrosion.** Exfoliation corrosion is the visible evidence of intergranular corrosion. This type of corrosion shows itself by the "lifting up" of the surface grains of a metal which is caused by the force of expanding corrosion occurring at the grain boundaries just below the metal's surface. This type of corrosion is most often seen on metal surfaces having a rough finish. The rougher, more strained, and less uniform a surface, the sooner corrosion will start, and the more localized the action will be.

22-19. **Concentration Cell (Differential Environmental) Corrosion.** Concentration cell corrosion occurs when several areas of a metal surface are in contact with different concentrations of the same electrolyte. Corrosion results from a difference in composition of the electrolyte and from the difference in concentration. Both conditions cause the corrosion of metals. An example of dissimilar environments is shown in figure 120.

22-20. There are three types of concentration cell corrosion: (1) metal ion concentration cells, (2) oxygen concentration cells, and (3) active-passive concentration cells.

22-21. *Metal ion concentration cells.* Metal ion concentration cells corrosion consists of different concentrations of metallic ions in various parts of water. A high concentration of metal ions will exist under the surfaces where the water is stagnant. A low concentration will exist adjacent to the crevice which is created by the raised surfaces. An electrical potential will exist between the two points. The area that has the high ion concentration will be anodic and will corrode.

22-22. For example, where a large object, such as a pipeline, passes through different soil environments, major corrosion cells extending over several miles may be established. Several amperes of current may flow in the metal of the pipeline as a result of this condition. Corrosion

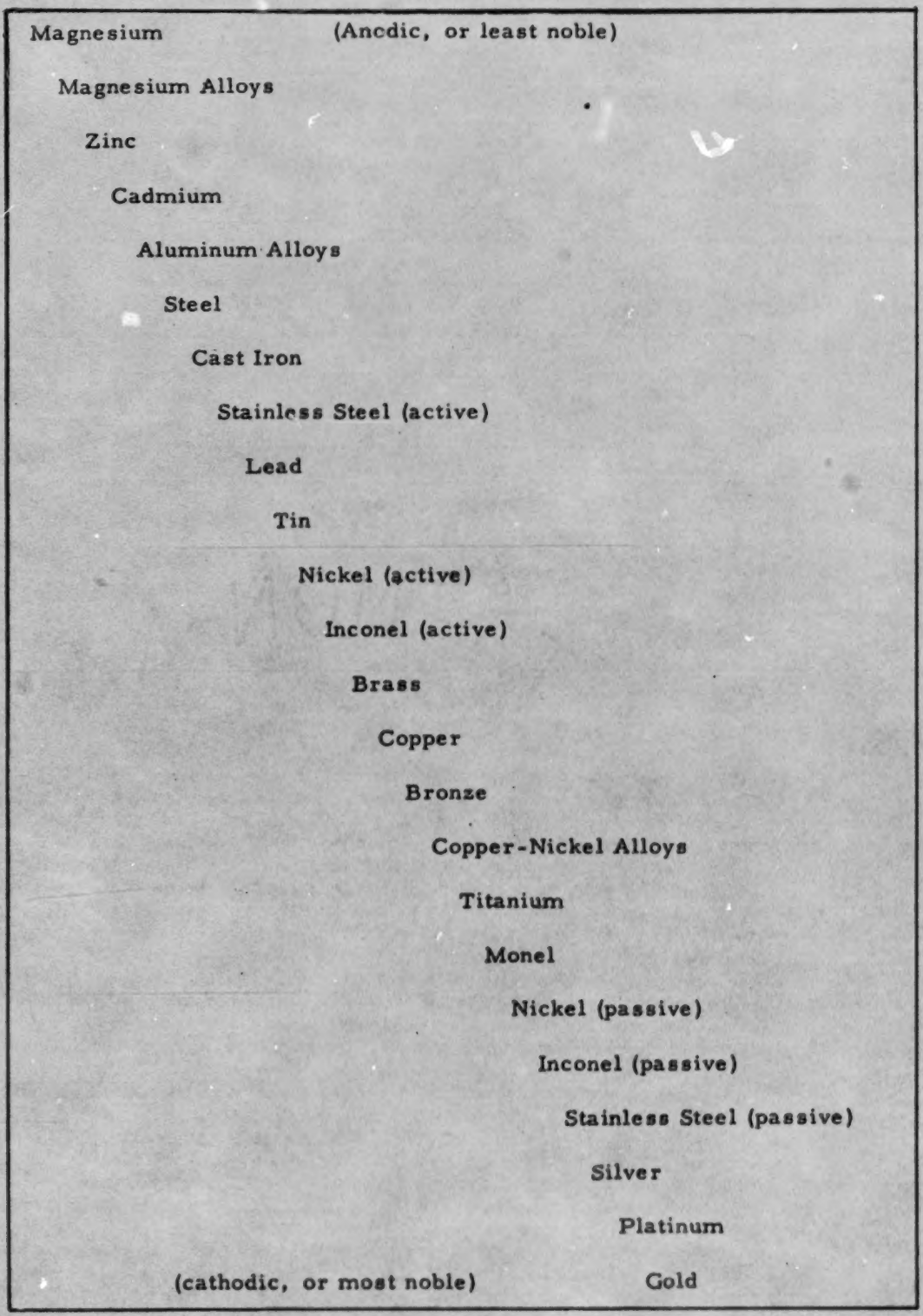
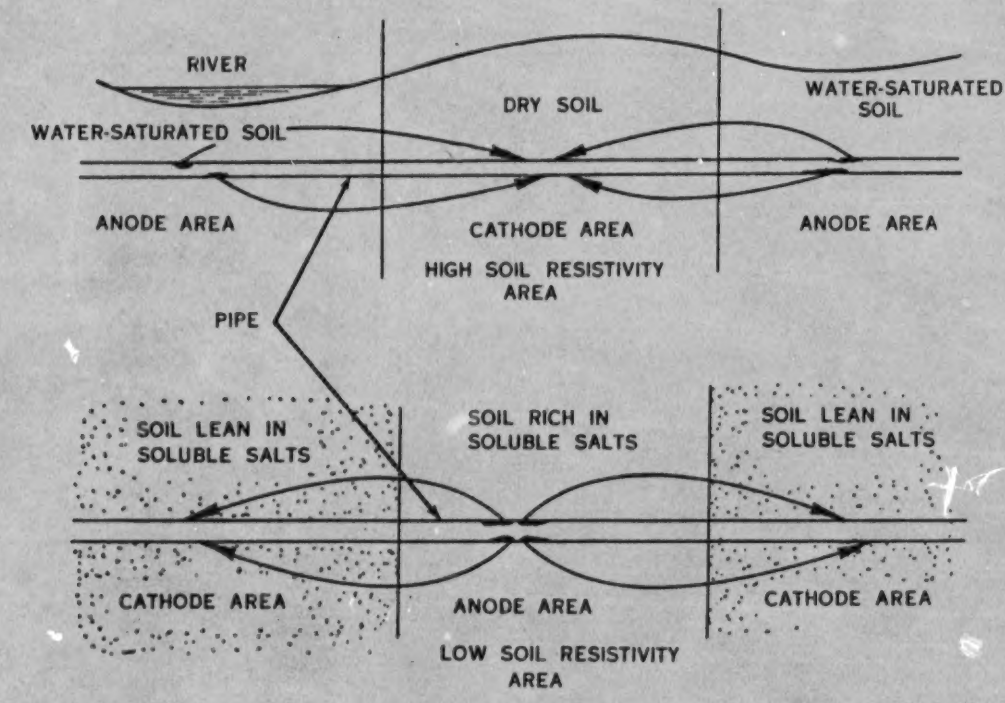


Figure 119. Metal compatability.

of the pipeline will occur where the current leaves the pipe surfaces.

22-23. *Oxygen concentration cells.* Oxygen concentration cell corrosion occurs when a solution contains varying amounts of dissolved oxygen. A cell can develop at any point where the oxygen in the air is not allowed to diffuse into the solution. Typical locations of oxygen concentration cells are under either metallic or nonmetallic deposits (dirt) on the metal surface and under faying surfaces such as riveted lap joints. Oxygen cells can also develop under gaskets, wood, rubber, plastic tape, and other materials in contact with the metal surface. Corrosion will occur at



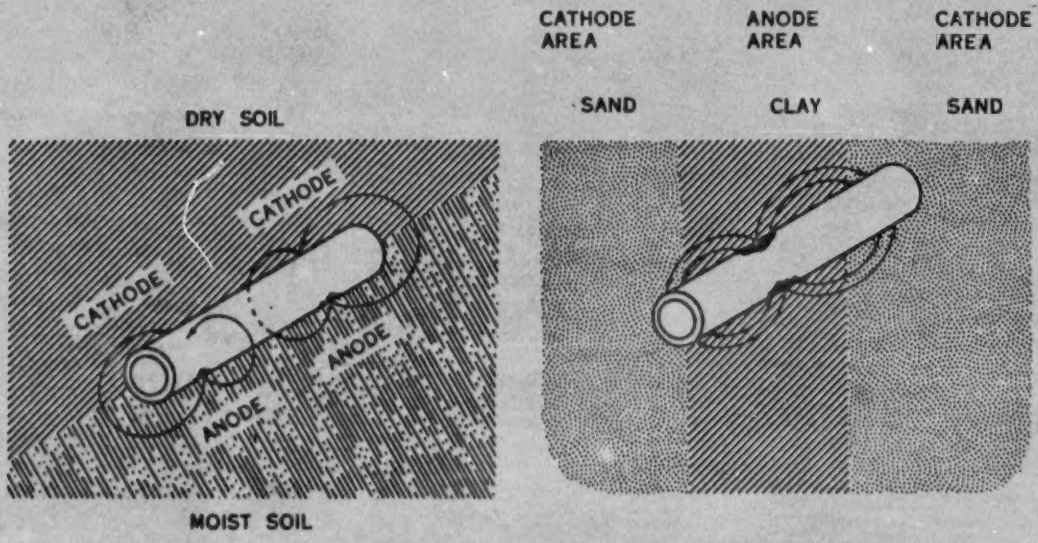


Figure 120. Dissimilar environmental corrosion.

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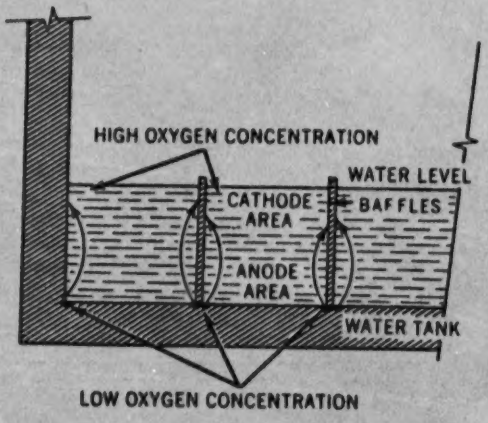

Figure 121. Low-oxygen concentration areas.

the area of low oxygen concentration (anode), as illustrated in figure 121.

22-24. *Active-passive cell.* Active-passive cell corrosion is usually found on metals which depend on a tightly adhering passive film, usually an oxide, for corrosion protection.

22-25. The corrosive action usually starts as an oxygen concentration cell, e.g., salt deposits on the metal surface in the presence of water containing oxygen can create the oxygen cell. The passive film will be broken beneath the dirt particle by the corrosion action of the oxygen cell. Once the passive film is broken, the active metal beneath the film is exposed to the corrosive attack. An electrical potential develops between the large area of the cathode (passive film) and the small area of the anode (active metal). Rapid pitting of the active metal will result as shown in figure 122.

23. Causes of Corrosion

23-1. The action of corrosion on pipelines, structures, and equipment conveying water, petroleum, and gases is a problem of vast importance. In our homes, corrosion and its products eat away the metal walls of hot water heaters and pipes. When leakage occurs, the heater or pipes are replaced. The Army has similar problems, but they are much greater. Instead of maintaining a few feet of pipe as we do in our homes, the Army maintains thousands of feet. Thus, if the effect of corrosion on Army equipment can be decreased, a substantial saving can be made.

23-2. Corrosion may develop under a number of various conditions, among them are mill scale, cinders, dissimilarity of pipe surface, different soil conditions, stray currents, dezincification, graphitization, and hydrogen embrittlement.

23-3. **Mill Scale.** Mill scale embedded in the walls of iron pipe during its manufacture is one cause of pipe corrosion. The mill scale actually becomes the cathodic area, the iron pipe becomes the anodic area and conductor, and the moist soil becomes the electrolyte. Current leaves the iron pipe wall, passes through the electrolyte soil to the mill scale, and returns to the iron pipe. This electrochemical action causes severe pitting of the pipe metal at the anodic areas. Continued action of this type will eventually weaken the pipe and cause it to fail.

23-4. **Cinders.** Another type of corrosion occurs when iron pipe is laid in a cinder-fill in direct contact with the cinders. The cinders and the iron pipe constitute the dissimilar metals, with the pipe forming the anodic area; the cinders, the cathodic area, and the highly ionized soil serving as the electrolyte. The current leaves the pipe through the soil to the cinders and returns to the pipe. Severe corrosion occurs at the points where the current leaves the pipe. The galvanic corrosion wears away the pipe at an accelerated rate because of the nonpolarizing effect of the cinders and highly ionized soil contamination of the cinders.

23-5. **Dissimilarity of Pipe Surface.** This type of galvanic corrosion occurs when there are bright or polished surfaces on some areas of the pipe walls in contact with suitable electrolytic soil. These bright surfaces become anodic to the remaining pipe surface. In a highly ionized soil, the polished surfaces corrode at an accelerated rate, weakening the pipe at that point. These bright surfaces may be made by a pipe wrench producing scars and scratches on the pipe when it was assembled. The threads on both ends of a coupling may expose shining surfaces which corrode easily. Corrosion in the threads will eventually cause the perforation of the pipe wall.

23-6. **Different Soil Conditions.** This is a general corrosion problem especially prevalent in highly alkaline areas. Corrosion currents leave the pipe wall into compact soils and enter the pipe wall from light sandy soils. The intensity of the corrosion currents and the resulting rate

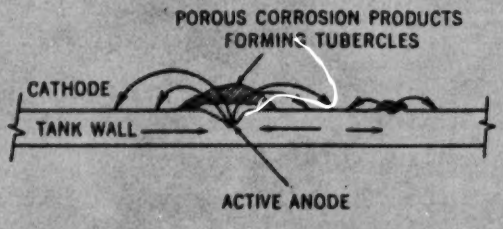

Figure 122. Action of low-oxygen corrosion.

of corrosion at the anodic areas of the pipe are directly proportional to the conductivity of the soil. Earth current meters are used to determine the location of the anodic and cathodic areas and the extent to which corrosion current exists. This meter determines if the pipe requires protection.

23-7. **Stray Currents.** Direct-current circuits that pass in and out of an electrolyte usually stray currents, many of which are a direct cause of corrosion. This condition poses the greatest problem in the vicinity of electrical transportation systems, electrified coal mines, or manufacturing plants where their direct-current distribution system requires a ground as a complete or partial circuit return. If a metallic structure, such as a tank or pipeline, is laid in such an area, a large galvanic cell is created, making a perfect setup for corrosion. Corrosion does not occur at the point where the current enters the structure because it is cathodically protected. However, at the section where the current leaves the structure, severe stray current corrosion occurs. Over a period of a year, this type of corrosion has been known to displace as much as 20 pounds of pipe wall for every ampere of current.

23-8. **Bacteria.** Biological corrosion is another distinct type of corrosion resulting from electrolytic or galvanic cell action of minute organisms. It is the deterioration of metals by corrosion processes which occur as either a direct or indirect result of the activity of certain bacteria, particularly in water or soil environment. These organisms causing bacterial corrosion are bacteria, slime, and fungi.

23-9. Microbiological corrosive action in the soil is due to physical and chemical changes in the soil by the action of these organisms. Some bacteria types are responsible for the production of active galvanic cells. These cells are produced by the variations of oxygen content in the soil (differential aeration) or the reduction of the hydrogen film over the cathodic areas (depolarization).

23-10. Bacteria are mostly found in highly water-logged, sulfate bearing, blue clay soils. The bacteria concentration as well as the corrosion rate varies considerably with the different seasons of the year. Cast iron and steel pipe are corroded mostly by the sulfides produced by the bacteria.

23-11. **Dezincification.** Dezincification is a selective corrosion which occurs in copper and zinc alloys. When alloys of this kind (brasses) are exposed to this type of corrosion, the zinc will dissolve out of the alloy leaving only the copper. Since most pipe fittings are made of brass, dezincification attacks may weaken these fittings to the point of failure. In this case, the zinc ions go into solution, leaving the copper. The solution may be impure water or oil that acts as an electrolyte.

23-12. **Graphitization.** Graphitization, or graphitic softening, is a peculiar form of disintegration which attacks grey cast iron. Cast iron is an alloy made of iron and carbon, the carbon being in the form of graphite. When cast iron with such a composition is subjected to graphitization, the iron dissolves out, leaving behind only the graphite. This action leaves cast iron weakened mechanically. However, after graphitization, the graphite pipe may last for many years if it is not subjected to any mechanical forces or sudden pressures.

23-13. **Hydrogen Embrittlement.** Hydrogen embrittlement is a term applied to metal that becomes brittle due to the action of hydrogen on its surface. When hydrogen forms on the surface of steel, the action of the hydrogen may form blisters or actually embrittle the metal. It has been demonstrated that hydrogen liberated near the surface of steel in an electrolyte will diffuse into the metal quite rapidly. This hydrogen picked up by the steel in an atomic state causes the steel to become brittle.

23-14. When the production of atomic hydrogen at the surface of the metal stops, the hydrogen leaves the metal in a few days, and the metal again regains its original ductility.

23-15. It has been found that carbon steels are affected by hydrogen embrittlement according to the hardness in the steel. The harder the metal the greater is the susceptibility to hydrogen embrittlement. Hydrogen embrittlement in carbon steels is also increased by the presence of stresses.

24. Corrosion Control

24-1. How can you control corrosion? Now that you know what corrosion is and what causes it, you must know how to control it. Basically, the same principle that causes corrosion is used to counteract corrosion. This is done in several ways, but the most common are known as passivation and cathodic protection.

24-2. **Passivation.** A passivator is an inhibitor which changes the potential of a metal to a more cathodic value. An inhibitor is a chemical substance or mixture which, when added to an environment usually in small concentration, effectively decreases corrosion. Figure 123 lists several types of mixtures for passivating metal surfaces. Now, the term "passivity" may be defined as the property by which certain metals become inactive in a specific environment. Met-

als that do not usually form protective films under service conditions may be protected by immersion in chemical baths containing inhibitors. Passivity of a metal, such as stainless steel, is gained by the formation of a protective film on the metal's surface by its absorption of atoms or ions.

24-3. By either of the above definitions, passivation of a metal surface serves to make the surface more resistant to corrosion by either physical or chemical treatment. One is based on the corrosion behavior of the metal or alloy, and the other is based on the electrochemical behavior of the metal or alloy.

24-4. The passivity of metals can be attributed, directly or indirectly, to a protective film which changes the galvanic potential of the metal or alloy in a more noble direction. For example, the inhibiting action of the chromate ion in zinc chromate priming paint provides protection by both passivation and mechanical means. The zinc chromate diffused in the paint provides a concentration of chromate ions on the metal's surface and tends to passivate the base metal. The chromate film shares electrons from surface iron atoms to make the metal surface less reactive and more noble in the galvanic series. Sodium nitrate is also used as a passivator and will render iron several tenths of a volt more noble

Type of Coating	Metal	Solution	Application
Zinc	Iron, Steel	5 to 10 percent hydrochloric acid/water solution for 5 to 15 seconds. (76°F.)	Dip or brush
Cadmium	Tin	Same as above (except 68°-77°F.)	Dip or brush
Tin	Iron, Steel	4 oz. concentrated sulfuric acid .4 oz. tartaric acid .4 to 8 oz. animal glue .13 oz. beta-naphthol for each gallon of water in tank (68° to 77°F.) Apply 10 to 30 amperes per sq. ft. metal	Immerse (until desired thickness is obtained)
Chromic-Nitric-Hydrofluoric Acid Pickle	Used for pickling all types of castings to passivate surface before machining	37.5 ± 2.5 oz. chromic acid 3 ± .5 fluid oz. nitric acid 1 ± .2 fluid oz. hydrofluoric acid for each gallon of water in tank. (70° to 90°F.)	Immerse 30 seconds to 2 minutes
Electroplate	Stainless Steel	1 part sulfuric acid in 4 parts water. Apply 200-amperes per sq. ft.	Immerse
Manganese	Ferrous metals. (Used to pickle parts that will go into long term storage or as a base for paint)	55 lbs. liquid manganese 33 lbs. liquid zinc phosphate 20 lbs. degreased steel wool per 100 gallons of water (205° to 210°F.)	Immerse 45 minutes (shake at intervals)
Nickel	Brass/Copper Steel/Aluminum	44 oz. nickel sulfate 5 oz. nickel chloride 5 oz. boric acid per gallon of water in tank. Apply 20 to 100 amperes per sq. ft.	Immerse

*NOTE: Never add water to an acid when mixing any acid solution. Slowly add the acid to the water

Figure 123. Passivation solutions.

than iron in distilled water. The nitrate ion is oxidizing in nature and, like chromates and other oxidizing passivators, reduces corrosion.

24-5. The use of metallic coatings and claddings is another way of making a metal passive to its environment. This means of protecting metal plates its surface with another corrosion-resistant metal. In some cases, plating gives the base metal a hard wear-resistant surface in addition to protection against corrosion.

24-6. Anodic coating can be applied to magnesium and zinc as a protection against corrosion. The protective oxide film provided by anodic treatment is of the same general type as that afforded by the natural oxide film. However, the natural film is very thin; thus, anodic coatings, because of their greater thickness, uniformity, and abrasion resistance, offer better protection against corrosion. Look again at figure 123 and study the types of passivation applicable to different metals as well as the chemicals used for passivation.

24-7. Passivation by the electron theory deals specifically with metals and alloys that become more noble because of their electrochemical behavior. In application, advantage is taken of the inhibiting action of ions in protective coatings which passivate by both electrochemical and mechanical means. Coatings and claddings are also used and in many cases provide the most economical solution to the corrosion problem.

24-8. **Cathodic Protection.** Cathodic protection is a method used to protect metal structures from the action of corrosion. As explained before, galvanic cell corrosion is the major contributing factor to the deterioration of metal by electrochemical reaction. The area of a structure that corrodes is the anode or positive side of the cell. Corrosion occurs when the positive electric current leaves the metal and enters the electrolyte. Galvanic cathodic protection is designed to stop this positive current flow. When the current is stopped, the corrosive action stops and the anodes disappear. This type of protection depends upon the neutralization of the corroding current and the polarization of the cathode metal areas.

24-9. Galvanic cathodic protection is a means to reduce or prevent the corrosion of a metal surface by the use of sacrificial anodes or impressed-current methods. The sacrificial anode method is known as the galvanic anode method and the latter method merely as the impressed-current method. These two methods can be used separately or in conjunction with each other, depending upon the corrosive characteristics of the electrolyte surrounding the structure.

24-10. *Galvanic anode method.* The galvanic anode method of cathodic protection uses an electrode referred to as a sacrificial anode that corrodes to protect a structure. This sacrificial anode is electrically connected to and placed in the same electrolytic area of the structure. The anode used to protect iron or steel structures should be made of magnesium or zinc so that it will produce a sufficient potential difference to cause the structure to become a cathode. The action of this type of galvanic protection causes the electric current to flow from the sacrificial anode through the electrolyte to the structure to be protected. The electrical connection between the two metals completes the circuit and allows the current to return to the corroding metal. The sacrificial anode becomes the anode of the established dissimilar metal galvanic cell, and the structure to be protected becomes the cathode. The current from the sacrificial anode is intense enough to oppose or prevent all positive current flows from leaving the anodes in the structure to be protected. The prevention of the positive current flow from the anodic areas in the structure reduces the corrosion rate to almost zero.

24-11. Galvanic cathodic protection is used in areas where the corrosion rate is low and electric

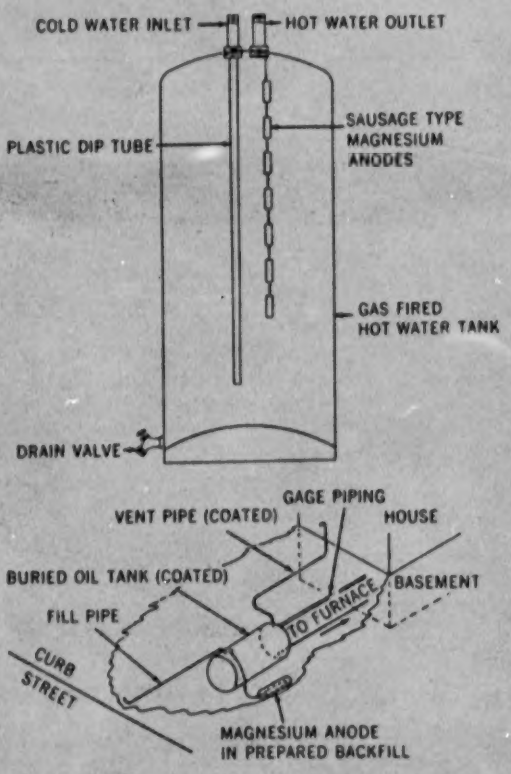

Figure 124. Galvanic cathodic protection.

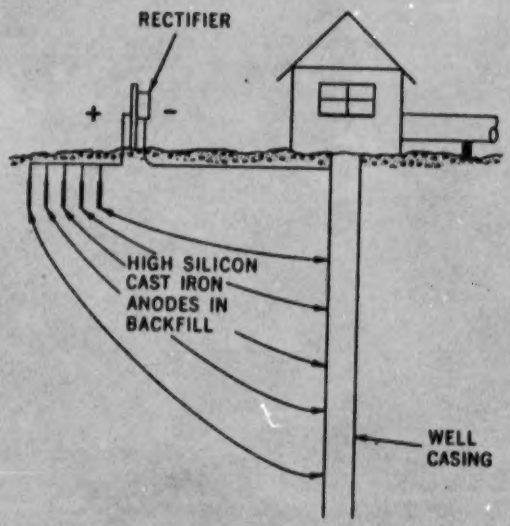

Figure 125. Impressed-current cathodic protection.

power is not readily available. Figure 124 shows a typical example of galvanic cathodic protection.

24-12. *Impressed-current method.* The impressed-current method of cathodic protection is designed to protect large metal structures located in corrosive areas. With this method of protection, a source of alternating current is required. In addition, a rectifier is needed to obtain the required direct-current potential.

24-13. The basic principal of the impressed-current method is merely the application of the galvanic cell reaction. The component parts of this method are: the cathode which is the metal structure to be protected, the anode made of suitable anodic material, the electrolyte or ground which is the ionized corrosive material, and the rectifier and various connections which serve to complete the electrical circuit. The operation of this method depends on the rectifier which forces direct current from the anode through the electrolyte (ground) to the metal structure to be protected. This method causes the metal structure to be the cathode, suppresses all anodic currents from it, and in turn prevents corrosion of the structure. Figure 125 shows a setup of an impressed-current method of cathodic protection.

25. Metal Identification

25-1. Unknowingly, you identify metal every day; for instance, a penny is made of copper, dimes and quarters are made basically of silver, and nickels are made of nickel. You can identify them by looking at them. Some metals can be identified by their use, such as aluminum for aircraft skin, and copper for electrical wire. However, this general classification is not good enough for the purpose of corrosion control, because if you misidentify a type of metal, the work you do may damage the metal or create a condition that will increase the possibility of corrosion. By misidentifying metal, you may waste your efforts, damage material, or cause corrosion.

25-2. The first and one of the most important steps in fighting corrosion is to identify the material that has been attacked by corrosion or is to be protected against corrosion. There are other tests besides visual which will help you determine the type of metal. These are mechanical tests, chemical tests, and complex tests.

25-3. **Visual Examination.** Often visual examination will reveal numbers or color codes that will identify the metal. The Society of Automotive Engineers (SAE) and American Iron and Steel Institute (AISI) have established a means of identifying steels with numbers and colors.

25-4. *Number system.* The number system works in the following manner: A four- or five-digit number is used to indicate the type of steel. For example, 2330 is a number code identifying a certain steel. The initial number, 2, indicates the main alloying element; i.e., nickel in this case. See figure 126. The second digit, 3, indicates the percentage of the main alloying element other than carbon. Thus there is 3 percent nickel. The last two digits in the number indicate the amount of carbon expressed in hundredths of percent; our example indicates that the steel has 0.30 percent carbon.

25-5. In the case of a five-digit number, the second and third digits are used to express the percent of the main alloying element when this figure requires more than one digit; i.e., 1.50 percent, 18.00 percent, etc.

25-6. In the case of plain carbon steel, 1095, the same system of interpreting the number is used except that the digit 1 represents carbon steel, and, since there is no main alloying element other than carbon, the second digit is always 0.

25-7. *Color code system.* A color code system linked to the numerical system of identifying the various alloys is used to mark these alloys. At present there are two color code systems in use for identifying metals and alloys. One system is the old SAE-AISI system related primarily to steel, and the other, a new one, changes the old system and also includes aluminum alloys and copper alloys.

25-8. This new system of identification has its own color code breakdown which differs from the old SAE-AISI system. As described in Technical Order 42D-1-3, there are ten colors used

in this system to represent the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0. Figure 127 helps to explain this point. These ten colors are also used to represent letters F, H, O, T, W, A, B, C, D, and S.

25-9. A combination of these colors, representing a combination of numbers and letters, is used to mark the material to denote its general composition and condition where applicable. In the example in figure 128 you see that the aluminum alloy tubing is marked green, black, green, orange, space, yellow, and red. By comparing these colors with the numbers on the chart in figure 127, you can identify this metal as 20–25–T6.

25-10. A further test in identifying metals is to check for markings such as manufacturers' part numbers or specification numbers. When such data are visible, they should be checked against part numbers, or group numbers shown in the 00–25–113 series of technical orders or alloy groups and material specifications.

25-11. When the specimen cannot be identified by part number or specification markings, examine its physical appearance and determine its possible common use. Check the color of the

Type of Steel	Numerals & Digits
Carbon Steels	1XXX
Plain Carbon	10XX
Free Cutting (Screw Stock)	11XX
Manganese Steels	13XX
Nickel Steels	2XXX
0.50% Nickel	20XX
1.50% Nickel	21XX
3.50% Nickel	23XX
5.00% Nickel	25XX
Nickel-Chromium Steels	3XXX
1.25% Nickel, 0.60% Chromium	31XX
1.75% Nickel, 1.00% Chromium	32XX
3.50% Nickel, 1.50% Chromium	33XX
3.00% Nickel, 0.80% Chromium	34XX
Corrosion and Heat Resisting	30XXX
Molybdenum Steels	4XXX
Chromium-Molybdenum	41XX
Chromium-Nickel-Molybdenum	43XX
Nickel-Molybdenum	46XX & 48XX
Chromium Steels	5XXX
Low Chromium (0.60% to 1.10%)	51XX
Medium Chromium (1.20% to 1.50%)	52XXX
Corrosion and Heat Resistant	51XXX
Chromium-Vanadium Steels	6XXX
Tungsten Steels	7XXX & 7XXXX
Chrome-Nickel-Molybdenum Steels	8XXXX
Silicon-Manganese Steels	9XXX

* The Sulfur content of these steels is higher than that normally found in plain carbon steels. These are fast cutting steels usually used for screw stock.

Figure 126. Numerical index for steel identification.

COLOR IDENTIFICATION NUMBER		COLUMN 1	COLUMN 2	COLUMN 3
Federal Standard No. 595	ANA Bulletin 166	Color	Number	Letter
1520	501	Blue	1	F
1460	503	Green	2	H
1405	504	Olive Drab	3	O
1310	506	Yellow	4	T
1205	508	Orange	5	W
1105	509	Red	6	A
1010	510	Maroon	7	B
1755	511	White	8	C
1645	512	Gray	9	D
1770	*622	Black	0	S

* ANA Bulletin 157

Figure 127. Identification marking code.

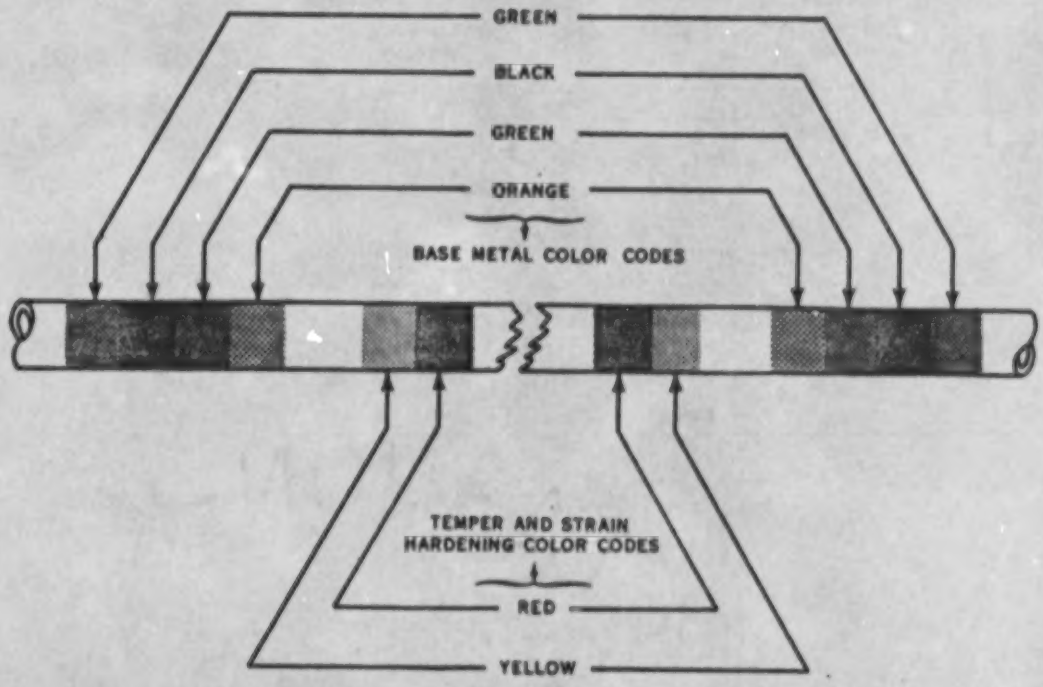

Figure 128. Identification markings.

metal. Is the color silvery, like polished aluminum or magnesium; yellow, like brass or gold; gray, like zinc or lead? Its color may guide you as to the alloys or elements to test for.

25-12. **Mechanical Testing.** If a metal cannot be positively identified by visual examination, the next step is to see if it is attracted by a magnet and to perform a spark test.

25-13. *Magnetic testing.* Magnetic testing consists of determining whether the specimen is attracted by a magnet. The magnet must be free swinging from a chain, ring, or string. Usually, a metal attracted by a magnet is iron, steel, or iron base alloys containing nickel, cobalt, or chromium. However, there are exceptions to this general rule. This test can serve only as an initial step in identifying a specimen and never as a final test.

25-14. Strongly magnetic metals include pure iron, pure nickel, pure cobalt, iron-nickel-cobalt alloys, and alnico. Lightly magnetic alloys include stainless steels and monel steel. All other metals and alloys are nonmagnetic.

25-15. *Spark testing.* Some metals can be readily identified by characteristic sparks thrown off when the specimen is held against a high-speed grinding wheel. The spark streams may vary from a few tiny sparks to a shower of sparks. Skill in spark-testing takes practice. When possible, compare the sparks thrown off by the unknown specimen with spark streams from known samples. Standard samples of known specifications should be maintained for comparison purposes. When testing, hold the specimen with a firm, even pressure against the top of the revolving grinding wheel. The surface of the grinding wheel should be cleaned frequently to free the wheel of metal particles retained during prior use.

25-16. A high-speed bench grinder is recommended for spark testing. It should have a 6″ to 8″ wheel, medium grit composition, ½ to ¾ hp, 110 or 220 volt, 3,400 to 4,000 rpm. Always wear goggles when spark testing.

25-17. Metals and alloys that will produce a spark on a grinder include aluminum, brass, cadmium, copper, gold, lead, zinc, and antimony. Stainless steels and high-temperature alloys with iron and nickel base compositions will produce characteristic sparks. (See fig. 129). As a general rule, the more iron in a specimen, the lighter the spark will be. As the percent of iron decreases and the percent of nickel increases, the spark will darken.

25-18. **Chemical Spot (Acid) Test.** A spot test may be made by placing one or more drops of acid on the metal surface of a specimen to observe the reaction to the acid. Spot tests are based on the formation of characteristic colors produced by the reaction of the acid on the metal surface. A small surface of the specimen should be cleaned with an emery cloth, file, or grinding wheel before making a spot test.

25-19. Some of the acids needed for testing consist of:

(1) Nitric acid (concentrated).

(2) Hydrochloric acid (concentrated).

(3) Potassium ferricyanide (10 percent solution—dissolve 10 grams of potassium ferricyanide in 100 milliliters of water).

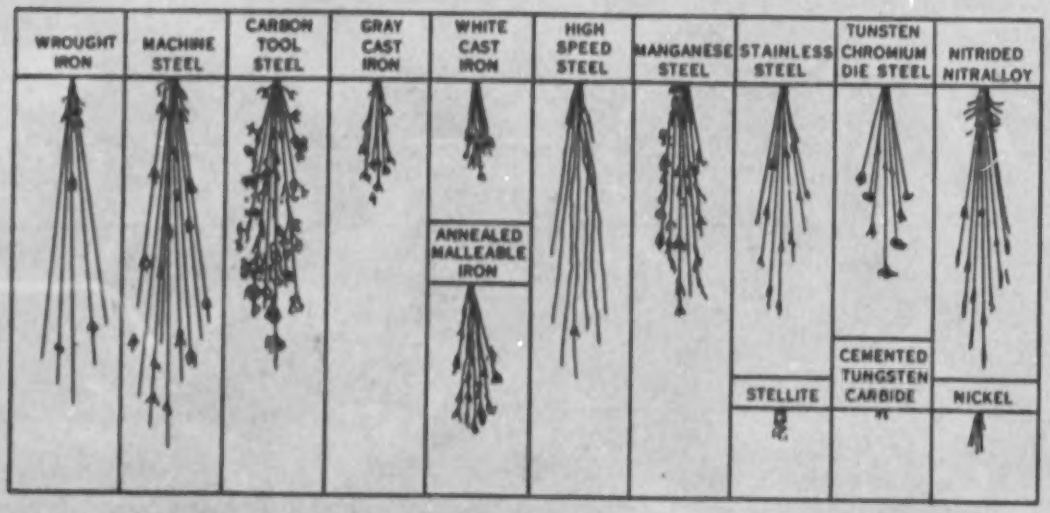

Figure 129. Typical spark streams.

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25-20. In nitric acid testing, place one drop of concentrated nitric acid on a clean metal surface. The following reaction should result:

Metals	*Reaction*
Brass	Blue-green
Cadmium	Yellow
Cobalt (pure)	Red
Copper	Blue-green
Copper-nickel	Blue-green
Magnesium	Effervescent—no color
Monel	Green
Nickel (pure)	Pale green
Silver	Gray-white
Tin	White
Zinc	Effervescent—black (brown fumes)

25-21. In nitric acid—diluted (50 percent acid and 50 percent water) testing, place one drop of diluted nitric acid on a clean metal surface. The following reaction should result:

Metals	*Reaction*
Iron	Brown-black
Manganese steel	Brown
Nickel iron alloy (5 to 80 percent nickel—balance iron)	Brown

25-22. Metals and alloys that will not react to nitric acid (concentrated or diluted) include: aluminum, antimony, cobalt, gold, high-temperature alloys, tungsten, lead, platinum, stainless steels, tantalum, and titanium.

25-23. Aqua regia acid consists of one part nitric acid mixed with three parts of hydrochloric acid. Since this mixture breaks down after 24 hours, you may make this test by placing one drop of nitric acid and three drops of hydrochloric acid on the spot to be tested. This solution should turn blue-green for cobalt-base alloys, and green for nickel-base alloys.

25-24. Potassium ferricyanide (10-percent solution) may be used to determine the iron content of nickel-base alloys since there is no simple spot test for determining the percent of nickel contained. This test may be made by adding a drop of potassium ferricyanide to the spot tested by aqua regia. The color reaction will be very dark blue-black for a high iron content, and a light blue for low iron content.

25-25. **Complex tests.** Complex tests are qualitative tests consisting of a spectrographic or chemical analysis and should only be used when a specimen cannot be identified by other tests or when the quantity involved warrants it.

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1-3-3- -32.718—Ft Belvoir

EXAMINATION

ARMY CORRESPONDENCE COURSE • ENGINEER SUBCOURSE 562

PAINTING I

CREDIT HOURS 2

TEXT ASSIGNMENT ..... Review previous assignments.

EXERCISES

1. Which of the following would you use to protect yourself against the dusts from sanding?

a. dispersoid respirator

b. chemical cartridge respirator

c. supplied air respirator

d. hard hat with goggles

2. A hazardous painting location is the interior of a tank. Which of the following locations might be more hazardous?

a. gymnasium
c. roof
b. closet
d. parking lot

3. Which of the following manuals would you select as a guide in the use of general safety measures?

a. TM 5-311
c. EM 385-1-1
b. TM 5-333
d. TM 5-680

4. You are the foreman of a crew about to start a painting job. You prepare your men by

a. avoiding discussion of possible hazards

b. giving a supplied-air ventilator to each

c. recording unanswered safety questions for answers immediately upon completion of job

d. using safety check list

5. When would you splice ladders to form a longer ladder?

a. when bottom ladder was metal

b. when there were safety shoes for only one ladder

c. if each ladder was not over 10 feet in length

d. never

6. Most paint products are flammable because they contain

a. oil
c. solvents
b. pigments
d. resin

7. Which of the following lists the primary uses of painting?

a. beautification, decoration, illumination

b. maintenance, safety, efficiency

c. camouflage and visibility

d. sanitation and fire retardance

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8. Which of the following lists earth colors?

a. yellow ocher, raw and burnt sienna, raw and burnt umber

b. pale blue, deep green, dark maroon

c. bright orange, dull red, light maroon

d. browns, voilet, pink

9. A paint drier is a

a. vehicle

b. binder

c. film softener

d. catalytic agent

10. What are paint volatiles?

a. catalysts c. thinners

b. plasticizers d. driers

11. Which of the following would you use to clean tools and equipment that you had used in painting with water-mixed paints?

a. turpentine

b. paint remover

c. commercial brush-cleaner

d. soap and water

12. What are the three primary colors of paint?

a. black, white, red

b. blue, red, yellow

c. green, purple, orange

d. bone black, iron blue, metallic brown

13. What are the three secondary colors of paint?

a. orange, green, purple

b. red, yellow, blue

c. black, white, brown

d. white, red, black

14. What do you use to fill the pores of absorbent surfaces in preparation for painting?

a. epoxy c. undercut

b. sealer d. primer

15. What would you use to remove plane marks and mill marks from a wood surface?

a. emery c. knife

b. scraper d. chisel

16. No maintenance is necessary on the

a. descaler

b. power buffer

c. orbital vibrator sander

d. portable belt sander

17. A painter in your crew has no previous experience with abrasive blasting equipment. How many hours operating time would you need to give him a basic knowledge of abrasive blasting techniques?

a. 12 to 24 c. 8 to 16

b. 16 to 20 d. 6 to 10

18. The abrasive blaster is operated by

a. steam

b. foot pedals

c. water pressure

d. compressed air

19. You could use a paint brush having nylon bristles when you are applying

a. enamel

b. lacquer

c. acid

d. water-thinned paints

20. What would you use to clean a brush that has been applying shellac?

a. linseed oil
b. paint remover
c. benzol
d. alcohol

21. Which type paint roller coater would you use in painting shingles?

a. high pile cover
b. lamb's wool cover
c. mohair cover
d. stippler

22. For proper operation of spray gun equipment, the gun must receive an adequate supply of

a. compressed air
b. linseed oil
c. alkali
d. paint thinner

23. The lubricating oil in the gasoline engine of a power-operated traffic-marker machine should be changed at intervals of

a. one to two weeks
b. 25 to 50 operating hours
c. 20 to 30 operating hours
d. 2 to 4 days

24. The size of a ladder is determined by its

a. weight
b. overall length
c. knots in wood
d. rung circumference

25. A ladder for a painting job is selected according to

a. height of building to be painted
b. height at which painter must work
c. distance it must be carried from paint shop
d. number of men in paint crew

26. What kind of knot would you use in making the boatswain's chair?

a. two half hitches
b. square
c. bowline
d. double bowline

27. What causes galvanic corrosion?

a. etching of the metal
b. pitting
c. stress
d. electrochemical action

28. While painting, you notice that a brass shutoff valve is bent out of shape. What type corrosion could be the cause?

a. dezincification
b. biological
c. intergranular
d. exfoliation

29. What kind of coating would you put on tin to prevent or retard corrosion?

a. zinc
b. cadmium
c. nickel
d. manganese

30. You place one drop of concentrated nitric acid on a clean metal surface. The metal turns white at that spot. What is the metal?

a. brass
b. copper
c. tin
d. monel

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ENGINEER

SUBCOURSE 563

PAINTING II

(APPLICATION)

CORRESPONDENCE COURSE PROGRAM

U. S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA

140

NRI 108

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INTRODUCTION

This subcourse is a continuation of the instruction in Memorandum 562, Painting I. It explains the preparation of wood, masonry, and metal surfaces to receive coatings of various kinds of paints. The present instruction also covers the methods used to estimate paint requirements, discusses the fundamentals of work inspection, and cites the standards that are used in evaluating acceptable workmanship.

The subcourse consists of four lessons and an examination as follows:

Lesson 1. Painting Wood Surfaces.

2. Painting Masonry Surfaces.

3. Painting Metal Surfaces.

4. Inspection of Surfaces.

Examination.

Twelve credit hours are allowed.

You will not be limited as to the number of hours that you may spend on the subcourse, any lesson or the examination. For statistical purposes, you are required to enter in the proper space on each answer sheet the number of hours spent in studying the text and solving the exercises.

Text furnished: Memorandum 563, Painting II.

To facilitate removal, answer sheets are bound in reverse order at the end of this pamphlet. Make sure that the number on the answer sheet is the same as the lesson on which you are working.

Each exercise has four choices with only ONE best answer. Select the choice that you believe is best, then turn to the answer sheet and mark an X through the letter representing that choice.

The examination will be sent to you when you have successfully completed all the lessons.

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LESSON 1

PAINTING WOOD SURFACES

CREDIT HOURS ---------- 3

TEXT ASSIGNMENT ---------- Chapter 1, Memorandum 563.

LESSON OBJECTIVE ---------- To teach you how to use the equipment and the techniques needed to apply various kinds of paints to wood surfaces.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. You are using pattern painting in camouflaging a building. How is this camouflage made effective?

a. colors chosen should blend with the background

b. patterns should be as small as possible

c. windows should be painted black

d. many colors should be used

2. Which of the following would you use to tighten a knot that "rattles" in a board that you must use?

a. type II calking compound

b. shellac

c. turpentine

d. thin screws

3. Paint deterioration has reached the advanced break-up stage when

a. checking and crumbling appear

b. flaking and scaling appear

c. disintegration lays bare enough wood for the boards to show distress of wood weathering

d. coating has reached the fissure stage and causes crumbling and flaking

4. You have just sanded and filled a hardwood floor. You want now to give it the most durable surface. Which of the following do you apply?

a. spar varnish

b. shellac

c. stain varnish

d. floor sealer

5. How would you use a liquid paint remover on a wooden surface?

a. brush it back and forth to prevent leafing action

b. allow it more time to loosen the old coating than you allow for a paste remover

c. continue to apply the remover until old coating loosens and drops off

d. allow softening action to continue until one stroke of the scraper will take off everything down to the bare wood

6. You are preparing a wood surface for painting. In using a scraping tool to remove bare wood as part of this preparation, you would

a. scrape against the grain

b. sandblast surface before the scraping

c. remove only enough wood to clear the surface of defects

d. wet the surface to raise nap of the grain

7. You are about to paint a double-hung window. You pull the top sash down slightly and also raise the lower sash. You do this in order to

a. paint the top rail, bottom rail, and the inside of the meeting rails

b. paint all glazing compound as a seal with panes

c. prevent sash from sticking

d. paint the muntin and the mullion rails

8. You can recognize mildew through a magnifying glass by the

a. granular mildew particles of irregular size and shape

b. numerous egg-shaped spores while mildew grows

c. numerous egg-shaped spores when mildew is dry and dormant

d. threadlike mycelia when mildew is dry and dormant

9. A pine floor may be finished with a transparent coating, but you decide to paint it because

a. it is easier to sand

b. pine is a softwood which dents and mars easily

c. it would require too many coats of varnish

d. it is too difficult to stain

10. You are preparing to repaint an exterior wood surface. You will use two coats on this surface if

a. you don't prime the surface

b. the old coating is less than 3 mils thick

c. the old coating is chalking

d. the initial paint is streaked

11. Which of the following is a disadvantage of using interior flat-finish paint?

a. produces eggshell surface that peels

b. fails to distribute light

c. must not be washed after it has dried

d. will not stand as many vigorous washings as a semigloss paint

12. You would use filler on hardwoods

a. before applying a transparent finish

b. with pores larger than those in birch

c. when applying an opaque finish

d. which are heavy and have small pores

13. You are using a roller to paint stippled surfaces. How do you make sure that the paint is properly applied and that coverage is adequate?

a. work very slowly so that the fast-spinning roller flings off no paint

b. paint from one edge of ceiling and toward the door

c. make crisscross strokes and finish with long parallel strokes

d. load roller to capacity

14. Calking compound comes in two grades. Both grades

a. are suitable for use at temperatures above 40° F

b. can be used in a calking gun

c. form hard exterior with soft underbody

d. can be thinned with butyl alcohol

15. You are about to apply water stain to finish some furniture. You first dampen the wood surface with water. Why?

a. gives stain more penetrating action

b. raises the nap in the grain of the wood

c. tones down stain color and facilitates blending

d. removes any filler from wood

16. What happens to the coating in the flatting stage of paint deterioration?

a. gradually loses its initial gloss

b. becomes powdery

c. rapidly becomes mildewed

d. develops checking and cracking fissures

17. You have just varnished an interior wood surface. You allow it to dry. You would rub this dried surface lightly with steel wool

a. if turpentine fails to remove any runs

b. if air bubbles appear

c. if second coat is to be applied against the grain

d. before applying the next coat

18. Blue stain on painted surfaces is caused by moisture and

a. a soluble dye in the wood

b. growth of certain fungi in sapwood

c. excessive heat

d. failure to use undercoat

19. You are applying a three-coat paint system to new wood construction. You gage the spreading rate to give a total coating thickness of how many mils?

a. 2 to 3 c. 4 to 5

b. 3 to 4 d. 5 to 6

20. Crawling occurs in freshly applied paint when the

a. new coating fails to wet the surface of the old paint

b. new coating is applied in damp air at 25° F or lower

c. solvents in new coating soften old coating

d. paint is applied in unduly thick layers

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LESSON 2

PAINTING MASONRY SURFACES

CREDIT HOURS ---------- 2

TEXT ASSIGNMENT ---------- Chapter 2, Memorandum 563.

LESSON OBJECTIVE ---------- To teach you the characteristics of masonry and the methods to use in preparing its surface to receive special paints.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. You have applied traffic, oil-base paint at a temperature of 70° to 90° F. This should dry to a gloss finish within

   a. 30 minutes
   b. 1 hour
   c. 2 hours
   d. 3 hours

2. Mortar to be used for repair of masonry joints is made by mixing

   a. 3 parts fine masonry sand and 2 parts portland cement
   b. 2 parts fine masonry sand and 1 part portland cement
   c. 1 part fine masonry sand and 1 part masonry cement
   d. 2 parts fine masonry sand and 1 part masonry cement

3. You are about to apply epoxy floor enamel to a concrete floor. How do you first prepare the floor?

   a. etch it with acid
   b. scrub the floor with trisodium phosphate and water
   c. treat it for alkalinity
   d. treat it for efflorescence

4. If you were applying a series of coats known as scratch, brown, and finish, you would be

   a. bedding sheetrock
   b. applying plaster during construction
   c. painting wet plaster
   d. removing rough spots from sheetrock

5. You are preparing an acid-water solution to remove glaze from a concrete surface. What is this solution and how do you use it?

   a. 10-percent muriatic acid solution; allow it to remain on the surface for 5 to 10 minutes, then hose it off with water
   b. 20-percent muriatic acid solution; allow it to remain on the surface for 20 to 30 minutes, then sponge it off with water
   c. 10-percent muriatic acid solution; apply the paint without removing residual powder on the surface
   d. 20-percent muriatic acid solution; apply the paint before acid evaporates

6. You are taping and bedding sheetrock joints. You use three-coat coverage because you want to

a. prevent the joint from bending

b. prevent tape from showing through

c. insure a proper buildup of compound to conceal the joint

d. prevent the joint cement from shrinking

7. You received 5 gallons of pigmented binder for a traffic marking job. How many pounds of glass spheres do you need?

a. 5 c. 30

b. 15 d. 40

8. To properly set a nail in sheetrock, you would strike the nail with sufficient force to get the nail head

a. ½ inch below surface and into gypsum core

b. even with surface hammer marks

c. 1/32" above surface

d. below the surface of the sheetrock

9. Which of these paints would you use on exterior masonry walls to attain some damp-proofing?

a. rubber-base c. cement-base

b. latex d. oil base

10. A varnish size coat for application to new plaster can be prepared by thinning each gallon of varnish with

a. 1 quart of turpentine

b. 1 quart of boiled linseed oil

c. 1 pint of turpentine

d. 1 pint of boiled linseed oil

11. You must remove loose and scaling deteriorated paint from a masonry surface. Which of the following do you use?

a. a sandblaster

b. heat

c. lacquer solvent

d. a lye-water solution

12. What type of traffic marking paint is used in conjunction with glass spheres?

a. traffic oil-base paint

b. plastic traffic-marking paint

c. traffic pigmented binder

d. gloss traffic-marking lacquer

13. You must apply a cement-water-sand paint to seal cinderblocks against moisture. Which of these do you use for this job?

a. calcimine brush

b. camel's hair brush

c. stiff-bristle brush

d. high pile roller

14. What is the composition of portland cement patching plaster?

a. 1 part Keene's cement and 1 part plastering sand

b. 1 part portland cement, 3 parts plastering sand, and ¼ part lime putty

c. 1 part portland cement, 1 part plastering sand, 1 part dehydrated lime

d. 1 part masonry cement and 1 part plastering sand

15. You have applied exterior latex paint on a masonry surface. When will this paint be dry to the touch?

a. 10 minutes

b. 10 to 30 minutes

c. 30 to 40 minutes

d. 1 to 2 hours

16. Latex paints can be applied to new concrete or masonry surfaces after a minimum aging period of how many weeks

a. 1 to 2
b. 2 to 3
c. 3 to 4
d. 6 to 8

17. You must remove loose plaster in order to repair a wall. How do you remove this loose plaster?

a. begin at center and work back into the surrounding area to a point where plaster is solid
b. use a hammer to remove all the old plaster together with the lath
c. thoroughly wet the damaged area with xylol before chipping out plaster
d. remove scratch coat first

18. You are repairing a mortar joint and suspect that the building is settling. You pack the joint to within ½" of the surface with

a. number 2 calking compound
b. cement mortar
c. type 2 putty
d. number 1 calking compound

19. You have made a solution of phenolphthalein in alcohol. You apply it to a concrete surface as a test. What are you testing for?

a. hardness
b. moisture
c. aggregate content
d. alkalinity

20. You find an interior concrete floor which shows signs of alkalinity. It is also subject to continual dampness. You decide to paint that floor with

a. porch and deck paint
b. varnish vehicle-floor paint
c. transparent silicone paint
d. rubber-base paint

LESSON 3

PAINTING METAL SURFACES

CREDIT HOURS 3

TEXT ASSIGNMENT ..... Chapter 3, Memorandum 563.

LESSON OBJECTIVE ..... To teach you the preparation of metal surfaces, how to identify and prevent corrosion, and how to use paint in preventive maintenance.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. Structural steel surfaces should be sandblasted and pretreated prior to painting when they are subject to

   a. water immersion and abrasion
   b. atmospheric exposure
   c. underground exposure
   d. interior exposure

2. You are steam cleaning metal. How many inches away from the surface do you hold the cleaning nozzle?

   a. 6 c. 18
   b. 12 d. 24

3. To prevent a burnished effect when power brushing metal surfaces, what is the minimum number of square feet that you should clean per minute?

   a. 1 c. 4
   b. 2 d. 10

4. A spray gun is in reasonably good operational condition when it can be adjusted to produce a spray 6 to 8 inches wide when the gun is held

   a. 6 to 10 inches from surface
   b. vertical to the surface
   c. 12 to 18 inches from the surface
   d. 18 to 24 inches from the surface

5. You are using stainless steel nails with lead covered heads to refasten corrugated metal siding to wood siding. Where do you place the nails?

   a. on top of the corrugations
   b. angled on side of corrugations
   c. in valleys between corrugations
   d. under the corrugations

6. You are operating a high-pressure spray gun. How many pounds of air pressure per square inch do you set?

   a. 60 to 80 c. 100 to 125
   b. 80 to 100 d. 130 to 150

7. Corrosion will not normally attack galvanized iron pipe unless

a. pipe is threaded

b. pipe has black iron fittings

c. pipe is used in hot water system

d. coating has been destroyed or damaged

8. When you mix the components of the vinyl wash coat, you would

a. add base solution to the acid

b. slowly add the acid component to the resin component and stir constantly

c. add acid very rapidly to resin component and let it set

d. add base solution to the resin component and shake

9. For proper operation and adjustment of a low-pressure spray gun, the pounds per square inch of air pressure should be between

a. 20 to 40 c. 60 to 80

b. 40 to 60 d. 80 to 100

10. How many inches should you hold the airless spray gun away from the surface that you are painting?

a. 4 to 6 c. 12 to 16

b. 8 to 10 d. 20 to 24

11. You have applied a chemical conditioner to a metal surface. You will know that the acid has reacted properly and has the proper dilution when

a. a dark color appears and surface is sticky

b. a powdery surface, grayish white in color, develops within a few minutes after application

c. insoluble gels form on the surface

d. application was maintained at a coverage rate of 250 to 300 square feet per gallon

12. A blasting job has removed practically all rust, mill scale, and other foreign matter from the surface of the metal. The surface is now not necessarily uniform in cleanliness and appearance. What do you call this type of blast cleaning?

a. vacuum c. white

b. brush-off d. commercial

13. You have a tungsten carbide nozzle which you use to apply sand as a surface abrasive. What is the life expectancy of this nozzle in hours?

a. 50 c. 100

b. 75 d. 300

14. What psi pressure would you use when sandblasting brick and mortar surfaces?

a. 40 to 60 c. 100 to 130

b. 80 to 100 d. 150 to 180

15. To assure intimate contact of the liquid with the metal, the chemical metal conditioner should be applied with a

a. whitewash brush

b. roller coater

c. low-pressure spray gun

d. high-pressure spray gun

16. You have filled a Zahn cup with lacquer. You do this because you want to

a. use a low-pressure spray gun

b. use an airless spray gun

c. measure viscosity

d. use a high-pressure air atomized spray gun

17. You are operating a sandblaster. You control the quantity of abrasive used by

a. air pressure

b. nozzle valve

c. nozzle orifice

d. hopper-control valve

18. You must remove old, hard paint and heavy, hard rust scale from a steel surface. You use

a. descaler tool

b. power brush

c. heat and brushing

d. power grinder

19. A blasting job has removed all corrosion products, all mill scale, all paint, and all other foreign matter from the surface of the metal. This type of cleaning is called

a. commercial

b. white

c. vacuum

d. brush-off

20. You must paint 500 gutter brackets. Which is the best method to use?

a. air-atomized spray

b. airless spray

c. electrostatic spray

d. dip

LESSON 4

INSPECTION OF SURFACES

CREDIT HOURS ---------- 2

TEXT ASSIGNMENT ---------- Chapter 4, Memorandum 563.

LESSON OBJECTIVE ---------- To teach you how to inspect surfaces, to evaluate the quality of paints and workmanship, and how to calculate surface areas.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. You notice that a painted metal surface shows early signs of scaling and flaking. Which of the following is a probable cause?

   a. poor surface preparation

   b. use of a conditioner

   c. mill scale

   d. use of washcoat in preparing the surface

2. Under average exposure conditions, a protective coating on exterior wood surfaces should have a life expectancy of how many years?

   a. 10 c. 6

   b. 8 d. 4

3. The atmosphere in contact with a surface being painted should be at or above 50° F. for water-thinned paints. What minimum temperature is set for using other coatings?

   a. 35° F c. 50° F

   b. 45° F d. 60° F

4. Which of the following would you measure with a dial indicator?

   a. dry-film thickness

   b. wet-film thickness

   c. corrosion pits

   d. base metal thickness

5. Paints which do not deteriorate by checking or cracking will waste away by

   a. crumbling c. flaking

   b. chalking d. scaling

6. What is the usual range in inches of a micrometer?

   a. 1 c. 3

   b. 2 d. 4

7. One gallon of enamel covers 500 feet of floor surface. How many gallons would you order to apply two coats to a floor area 60 feet long and 40 feet wide?

   a. 4 c. 8

   b. 6 d. 10

8. Which of the following is a factor in the covering capacity of a paint?

a. thickness

b. color

c. size of brush

d. number of painters

9. You are inspecting nailhead sets in a wooden surface. You make sure that

a. type II putty was used to fill the sets

b. surface had been primed before the sets were filled

c. nail sets were filled prior to priming and painting

d. they had been set at least ¼ inch below the surface

10. You would permit the painting of a wood surface if the moisture content of the wood did not exceed

a. 5%
c. 12%
b. 7%
d. 15%

11. Which one of the following would you select as a cleaner for a wood surface that you are about to paint?

a. scrapers
c. solvent
b. roughening tool
d. primer

12. Which of the following is used to measure film thickness on a test panel?

a. wet-film gage
c. dial gage
b. dry-film gage
d. micrometer

13. One gallon of paint covers 400 square feet of surface. How many gallons would you order to paint building walls that are 100 feet long, 50 feet wide, and 10 feet high?

a. 4
c. 8
b. 6
d. 10

14. You are the inspector on a construction job on your post. In your possession at all times you would have an up-to-date set of

a. submittals

b. change orders

c. specifications

d. daily diaries

15. When would you calibrate the dry-film thickness gage?

a. when the surface is slick or glazed

b. if it reads zero when in direct contact with the base metal

c. if it does not read zero when in direct contact with the base metal

d. when the base metal is pitted

16. What is a submittal?

a. a written directive

b. a sample of material or a manufacturer's certificate

c. a contact

d. plan of construction

17. If there is a difference between the specifications and the drawings, how is this resolved?

a. inspector decides

b. contractor decides

c. drawings will govern

d. specifications will govern

18. You have decided to use an oil-base paint on the exterior of a wooden building. How many square feet would a gallon of the paint cover?

a. 350
c. 250
b. 300
d. 200

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19. Which of the following is a suitable method for removing glaze from cleaned concrete and masonry surfaces?

a. roughening
b. solvent
c. vinyl wash
d. sandpaper

20. The daily diary that is kept during the contractural period is maintained by the

a. contractor
b. inspector
c. workmen
d. contract officer

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 563 ---------- Painting II.

LESSON 1 ---------- Painting Wood Surfaces.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 563.

1.	*a*	(par 2-7)	11.	*d*	(par 4-3*a*)
2.	*a*	(par 3-18)	12.	*b*	(par 1-8)
3.	*c*	(par 2-17*f*)	13.	*c*	(par 4-7)
4.	*d*	(par 4-31)	14.	*a*	(par 2-9)
5.	*d*	(par 2-24*c*)	15.	*b*	(par 4-38)
6.	*c*	(par 2-3)	16.	*a*	(par 2-17*b*)
7.	*a*	(par 3-21)	17.	*d*	(par 4-18)
8.	*c*	(par 2-21*a*)	18.	*b*	(par 2-21*b*)
9.	*b*	(par 4-25)	19.	*c*	(par 3-5*c*)
10.	*b*	(par 3-5*b*)	20.	*a*	(par 3-8*b*)

For further explanation, see Discussion sheet.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

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DISCUSSION

Exercise:

1. The patterns should be as large as practicable, and the colors should be chosen to blend with the background (a) for the camouflage to be effective.

2. If the center of the knot just moves in the board it can be secured with shellac; but if the center is loose enough to "rattle", it may be tightened by using a type II calking compound (a) which hardens as it dries.

3. When disintegration lays bare enough wood for boards to show distress of wood weathering (c), the coating has reached the stage of advanced breakup.

4. You should allow the filler to dry for 18 hours before proceeding. Floor sealer (d) provides a more durable surface than do shellac or varnish finishes.

5. With paste or liquid remover, the softening action should be allowed to continue until one stroke of the scraper will take off everything down to the bare wood (d).

6. Remove only enough wood to clear the surface of defects (c). If you remove too much, you could weaken the structural strength of the wood.

7. Pull top sash down slightly and raise the lower sash. This will allow you to paint the top rail, bottom rail, and the inside of the meeting rails (a). Reposition the sashes to paint the stiles, muntin, and mullion rails.

8. Mildew is characterized by threadlike mycelia when it is in the growing stage, and by numerous egg-shaped spores when it is dry and dormant (c). If you suspect mildew, use a magnifying glass to inspect the area.

9. Pine floors are usually painted because pine is a softwood which dents and mars easily (b). Hardwood floors are generally finished with transparent coatings.

10. When the old coating is less than 3 mils thick (b), two coatings are usually needed. The first coat should be a primer.

11. The flat finish can be washed occasionally, but it will not stand as many vigorous washings as a semigloss paint (d).

12. Hardwoods with pores larger than those in birch (b) are unsuitable for ordinary exterior painting. They require a filler to fill the pores before the application of paint.

13. Make several crisscross strokes and finish with long parallel strokes (c) in one direction. This sequence distributes the paint and insures coverage on stippled surfaces. (See figure 22.)

14. Grade I is soft and suitable for use in a calking gun, but Grade II has the consistency of glazing putty and is applied with a knife. Both grades are suitable for use at temperatures above 40° F (a).

15. Before applying water stain, dampen the surface with a wet cloth. This raises the nap in the grain of the wood (b). When the surface dries, the nap is removed by hand-sanding with very fine grit sandpaper. Figure 26 illustrates the process.

16. In the flatting stage of paint deterioration, the coating gradually loses its initial gloss (a). Flatting does not justify repainting.

17. Allow 24 hours for drying between coats. After one coat has dried hard, rub the surface lightly with steel wool before applying the next coat (d).

18. Blue stain is caused by moisture and the growth of certain fungi in sapwood (b). It occurs on surfaces exposed to condensation.

19. On new wood, the first coat should be primer and the last two coats finish paint. The spreading rate should be gaged to give a total coating thickness of 4 to 5 mils (c).

20. Crawling occurs when the new coating fails to wet the surface of the old paint (a). The new coating in this situation collects in drops as water does on a greasy surface.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 563 _____ Painting II.

LESSON 2 _____ Painting Masonry Surfaces.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 563.

1.	*b*	(par 11-5)	11.	*d*	(par 7-12)
2.	*d*	(par 7-6)	12.	*c*	(par 11-4)
3.	*b*	(par 10-4)	13.	*c*	(par 7-9)
4.	*b*	(par 9-3)	14.	*b*	(par 9-15)
5.	*a*	(par 7-2)	15.	*c*	(par 8-9)
6.	*c*	(par 9-28)	16.	*c*	(par 8-8)
7.	*c*	(par 11-7)	17.	*a*	(par 9-11)
8.	*d*	(par 9-29)	18.	*b*	(par 7-7)
9.	*b*	(par 8-7)	19.	*d*	(par 7-3)
10.	*a*	(par 9-20)	20.	*d*	(par 10-2)

For further explanation, see Discussion sheet.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

DISCUSSION

Exercise:

1. At 70° to 90° F, the paint should set to touch in 30 minutes, and it should dry to a gloss finish within 1 hour (b).

2. To repair a masonry joint, remove old mortar and loose material, cleaning the joint with water from a hose; then fill with mortar that you have made by mixing 2 parts of fine masonry sand and 1 part of masonry cement (d).

3. Before applying the epoxy floor enamel, you should first scrub the floor with trisodium phosphate and water (b). The floor must then be allowed to dry before you apply the epoxy enamel.

4. A series of three coats known as scratch, brown, and finish are used when applying plaster during construction (b).

5. You can use a 10-percent muriatic solution. Allow it to remain on the surface for 5 to 10 minutes, and then hose it off with water (a). Wear goggles and rubber gloves when using this acid, and be sure to add acid to water, not water to acid.

6. After the taping coat (par 9-26) has dried, you should apply a second and third coat of compound over all joints. The three-coat coverage will insure a proper buildup of compound to conceal the joint (c).

7. Pigment binder is used in conjunction with glass spheres; so you must check that you have both. The glass spheres should be applied at the rate of 6 pounds per gallon of pigment binder. (5 gal binder × 6 pounds = 30 pounds) (c).

8. Do not use a nail set to set the nails; use a hammer. Use sufficient force in the blow to recess the nail head below the surface of the sheetrock (d).

9. Latex (b) paint, particularly that made with polyvinyl acetate emulsions, is very suitable for use on exterior concrete and masonry. This paint is moisture and alkali resistant and has desirable deterioration characteristics.

10. Before applying calcimine paint to new plaster that has aged for the minimum time, you should apply a watered-glue or a varnish-thinned size coat. The varnish can be thinned by mixing 1 quart of turpentine (a) with a gallon of varnish.

11. Loose and scaling paint on masonry usually can be removed by using a lye-water solution (d). This breaks down and dissolves old paint so that it can be flushed from the surface with water.

12. Traffic pigmented binder (c) is the type of paint used in conjunction with glass spheres. This binder should be applied at the rate of not less than 100 sq ft and not more than 110 sq ft per gallon.

13. You apply the paint and scrub it into the surface with a stiff-bristle brush (c). Apply the paint heavily enough to fill the many small voids in the cinderblock.

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14. Portland cement patching plaster should be mixed on the job shortly before it is to be used. It is composed of 1 part portland cement, three parts plastering sand, and ¼ part lime putty (b).

15. Although latex paint dries to the touch in 30 to 40 minutes (c), it should not be applied in temperatures below 40° F.

16. Latex paint requires a shorter aging period for concrete and masonry surfaces than does oil-base paint, although an aging period of 3 to 4 weeks (c) is recommended.

17. To make the repair, you must remove all loose plaster. Begin at the center and work back into the surrounding area to a point where the plaster is solid (a). Replace defective laths and refasten all loose laths.

18. If you suspect that the building is settling, repair the mortar joints. Remove old mortar to a depth of about 2 inches, pack that opening with cement mortar (b) to within ½ inch of the surface, and then fill the remainder of the joint with number 1 calking compound.

19. The application of a few drops of a 1-percent solution of phenolphthalein in alcohol to concrete is a test for alkalinity (d). If alkaline is present, the drops of solution will turn pink, red, or purple.

20. A rubber-base paint (d) will resist alkali and should be used where the concrete is subject to dampness. This paint is superior to varnish-base paint in wear resistance, but it will not last with outdoor exposure.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 563 ---------- Painting II.

LESSON 3 ---------- Painting Metal Surfaces.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 563.

1.	*a*	(par 16-36)	11.	*b*	(par 15-4)
2.	*b*	(par 13-7)	12.	*d*	(par 13-19*b*)
3.	*b*	(par 13-10)	13.	*d*	(par 13-16)
4.	*a*	(par 16-12)	14.	*a*	(par 13-18)
5.	*a*	(par 14-8)	15.	*a*	(par 15-3)
6.	*b*	(par 16-9)	16.	*c*	(par 16-7)
7.	*d*	(par 12-3)	17.	*d*	(par 13-14)
8.	*b*	(par 15-6)	18.	*a*	(par 13-13)
9.	*a*	(par 16-9)	19.	*b*	(par 13-19*a*)
10.	*c*	(par 16-27)	20.	*d*	(par 16-2)

For further explanation, see Discussion sheet.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

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DISCUSSION

Exercise:

1. Structural steel surfaces which are subject to water immersion and abrasion (a) should be sandblasted to the base metal to obtain satisfactory results.

2. For effective cleaning, hold the nozzle approximately 1 foot (b) from the surface to be cleaned. Be careful to prevent the splash or overspray from contacting electrical equipment.

3. A burnished effect does not allow good adhesion of paint coatings and should be avoided. Generally a cleaning rate slower than 2 (b) square feet a minute is of little avail for better cleaning.

4. By rotating the spray gun cap or air nozzle, it is possible to produce a spray pattern about 6 to 8 inches wide when the gun is held 6 to 10 inches (a) from the surface.

5. When locating the nail fasteners on corrugated siding, place them on top of the corrugation (a) and not in the valley. Do not imbed them to the extent that the shape of the siding will be deformed.

6. For a low-pressure spray gun, the air pressure should be between 20 and 40 psi, but for a high-pressure gun, the air pressure should be between 80 and 100 psi (b).

7. Galvanized pipe is used in most water systems. Normally, corrosion will not attack this metal unless the coating has been destroyed or damaged (d).

8. Slowly add acid component to the resin component and stir constantly (b) while doing it. If the acid is added too rapidly, without thorough mixing, or if the base solution is poured into the acid, the mixture will gel and be unusable.

9. For a low-pressure spray gun, the air pressure should be between 20 and 40 (a) psi.

10. The airless spray gun is held 12 to 16 (c) inches away from the surface being painted. This distance is necessary because of the heavier material.

11. After the metal conditioner has been applied to a surface, the acid will react with the metal. When a powdery surface, grayish-white in color, develops within a few minutes after application (b), the acid has reacted properly and has the proper dilution.

12. Commercial (d) blast cleaning provides a good but not perfect blasting job, and includes the removal of practically all rust, mill scale, and other foreign matter from the surface of the metal.

13. The life of a tungsten carbide nozzle is 300 hours (d) applying sand. If steel grit is used as the abrasive, the life would be 2½ times greater.

14. The customary blasting pressure for structural steel work is about 80-100 psi, but the normal pressure used for sandblasting brick and mortar surfaces is 40 to 60 (a) psi.

15. The compound is easily applied with a whitewash brush (a). It can be also applied by spray, but the brush method is preferred in order to insure intimate contact of the liquid with the metal, and to avoid use of excessive amounts.

16. The Zahn cup is designed to measure viscosity (c) of fluids directly from their containers. It consists of a 44-mil cup with a hole and a wire handle, as shown in figure 48.

17. A hopper provides storage for the abrasive material. A hopper control valve (d) limits the quantity of abrasive used.

18. Chipping with a descaler tool (a) is occasionally necessary to remove old, hard paint and very heavy, hard rust scale. The descaler hammers its head needles against the surface, especially in inaccessible areas, such as grooves, crevices, rivets, and similar places.

19. White (b) metal blast cleaning removes all corrosion products, all mill scale, all paint, and all other foreign matter from the surface of the metal, leaving a surface that provides strong adhesion of the protective coating.

20. The dip (d) or flow-coat method is used for volume-production painting of certain items that are suitable for this painting method. The number and size of the gutter brackets make this dip method suitable.

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CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 563 ---------- Painting II.

LESSON 4 ---------- Inspection of Surfaces.

SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 563.

1.	*a*	(par 18-3)	11.	*a*	(par 19-2)
2.	*d*	(par 18-4)	12.	*d*	(par 19-20)
3.	*b*	(par 19-9)	13.	*c*	(par 18-19)
4.	*c*	(par 18-9)	14.	*c*	(par 20-6)
5.	*b*	(par 18-4)	15.	*c*	(par 19-15)
6.	*a*	(par 18-14)	16.	*b*	(par 20-8)
7.	*d*	(pars 18-19, 18-23)	17.	*d*	(par 20-7)
8.	*a*	(par 18-21)	18.	*a*	(par 18-23, fig 66)
9.	*b*	(par 19-2)	19.	*a*	(par 19-3)
10.	*c*	(par 19-2)	20.	*b*	(par 20-11)

For further explanation, see Discussion sheet.

All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.

DISCUSSION

Exercise:

1. The early failure of a protective coating is generally the result of poor surface preparation (a). This is especially true on metal surfaces which show early signs of scaling and flaking.

2. The protective coating on exterior wood surfaces should normally deteriorate by the chalking process. The coating should have a life expectancy of 4 (d) years under average exposure conditions.

3. During painting, the temperature of the surface and of the atmosphere in contact with the surface should be at or above 45° F (b) for other than water-thinned coatings.

4. Corrosion pits (c) can be measured with a dial indicator. The indicator is illustrated in figure 62.

5. Paints that do not deteriorate by checking or cracking will waste away by chalking (b) until they become too thin to hide the wood.

6. The range of a micrometer is usually 1 inch (a). The size of a micrometer is the largest dimension that it will measure.

7. $60' \times 40' = 2400'$ floor area
$2400' \times 2 = 4800'$ two coats
$500' = 1$ gallon
$\frac{4800}{500} = 9.6$ or 10 gallons (d)

If two or three coats are used, the same amount is figured for each coat.

8. It is quite difficult to determine the covering capacity of paint. Thickness (a) is definitely a factor, along with method of application, roughness of surface, and absorption of surface.

9. All the surface must be checked to insure that nails have been properly set. Then the surface is primed before all holes and imperfections are filled with putty (b).

10. You should allow painting to proceed only when the moisture content of the wood does not exceed 12 percent (c) when measured by a moisture meter.

11. Wood surfaces about to be painted should be cleaned of dirt, oil, and other foreign substances with mineral spirits, scrapers (a) or sandpaper.

12. After the paint on the test panel has dried, its thickness is measured with an ordinary micrometer (d) having flat contact surfaces.

13. $100' \times 10' = 1000$ sq ft $\times 2 = 2000$ sq ft (two side walls)
$50' \times 10' = 500$ sq ft $\times 2 = 1000$ sq ft (two end walls)
3000 sq ft = total wall area

$\frac{3000}{(1 \text{ gal} = 400')} = 7.5 = 8$ gallons (c)

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14. You should keep an up-to-date set of specifications (c) in your possession at all times, and make sure that the contractor also has an up-to-date set. The specifications explain what the contractor has contracted to do.

15. The dial reading should show the thickness of the nonmagnetic shim. On a smooth, machined surface, the thickness gage should also read zero with the gage in direct contact with the base metal (c). It should be calibrated if it does not read zero.

16. The specifications will specify the type and gage of materials that are to be used, and may require a submittal. The submittal may be a sample of material or a manufacturer's certificate (b).

17. There will always be differences of interpretation. Any misinterpretation can change the entire concept. If there is a difference between the specifications and the drawings, the specifications will govern (d).

18. The paint coverage column (line 10) indicates that an oil-base paint would cover 350 (a) square feet on the wood surface.

19. The preparation of concrete and masonry surfaces to receive paint should include roughening (a) to remove glaze.

20. The daily diary is the most important record maintained by the inspector (b) during the contractural period. It is consulted many times by the engineer and the contracting officer.

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MEMORANDUM 563

PAINTING II

(APPLICATION)

U. S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA

NRI 108

PREFACE

In Memorandum 562, you learned about protective coating materials and equipment, safety in the use of ladders, scaffolds, and hoisting equipment, and identification of metals and corrosion products. This subcourse discusses the preparation of surfaces and the proper application of protective coatings to wood, masonry, and metal. In addition, the text covers inspection of surfaces.

Your work in this area is of vital importance to the Army. The success of any paint job will depend on you, the painter. Painting work is an important item in construction and overall maintenance operations. The life, operating efficiency, and economy of structures are influenced by the effectiveness of the protective coating you will apply. It is the purpose of this Memorandum to provide you with information that will aid you in doing your job well.

Keep this Memorandum for your own use after you have completed the subcourse.

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CHAPTER 1

Painting Wood Surfaces

THE PRIMARY purpose of painting exterior wood surfaces is protection. A secondary purpose of painting is to obtain a more pleasing appearance. Without the protection of paint or other protective coatings, wood undergoes weathering and deterioration. This roughens its surface. darkens its color, allows it to warp and cup, and wears its surface away about ¼ inch of thickness per century.

2. As an Army protective coating specialist, it will be your job to prepare surfaces and apply protective coating materials to buildings and other structures. How well you learn and prepare yourself for the job depends on your own personal desire and ambition. You can either become a protective coating specialist or you can be a dauber. The dauber is the man who can work only under close supervision and must be told, step by step, how to do the job. The protective coating specialist is a man with vast technical knowledge who knows what needs to be done, why it needs to be done, and how to do the job. Sooner or later, this man will become the dauber's supervisor.

3. This chapter deals with the preparation and painting of wood surfaces. Protective coatings for masonry and metal surfaces will be covered in later chapters. You must know how to properly prepare wood surfaces before they are painted. To help you do the best job possible, you should have a knowledge of the different types of wood and the characteristics of each.

1. General Characteristics of Wood

1-1. Woods are generally divided into either hardwoods or softwoods. The hardwoods are used much less than softwoods in building construction, especially on exterior surfaces. All woods vary greatly in their ability to retain paint. Among softwoods, paint coatings remain sound longest on lightweight boards with narrow growth rings. Edge-grain surfaces on the bark side will retain paint better than the pith side of flat-grain boards. The growth rings in softwood (see fig. 1) consist of a dense, darker colored part called the summerwood, and a soft, lighter colored part called the springwood. When paint coatings begin to fail, they do so first and continue faster on the widest streaks of summerwood. This is the reason woods with narrow growth rings have the best paintability.

1-2. Lumber may be sawed in either of two ways at the mill. The select and choice grades, used for building construction, are quarter-sawed, while the utility or lesser grades may be plane-sawed. The method of sawing at the mill has a lot to do with the grain in the finished lumber and the paint-retaining characteristics of that lumber. As a coating specialist, you should be able to recognize these grain characteristics at a glance. You have probably already determined that quarter-sawed lumber is better than plane-sawed. Now, let's find out why this is generally true.

1-3. **Quarter-sawed Lumber.** The main purpose for quartersawing is to produce lumber which has narrow growth rings and edge-grain surfaces. This type of lumber will not warp and cup, and it has good paintability. Figure 2 illustrates how a log is quarter-sawed at the mill and how boards are sawed from the quarters of the log. By examining the end grain of one of these boards, you can see how the growth rings produce a close edge-grain surface which is ideal for painting.

1-4. **Plane-Sawed Lumber.** Plane-sawed lumber is generally used in the construction of such things as fences and shipping crates. It is cheaper and faster to produce at the mill. Figure 3 shows the method of slicing, or flat-sawing, boards from the log. You can see how this method of sawing produces a flat-grain board, with wide bands of summerwood, which is less desirable for painting.

1-5. **Warping and Cupping.** Fresh-sawed lumber at the mill is green and full of moisture. It is stacked and bound in a manner to prevent warping and cupping as it dries out and cures. The

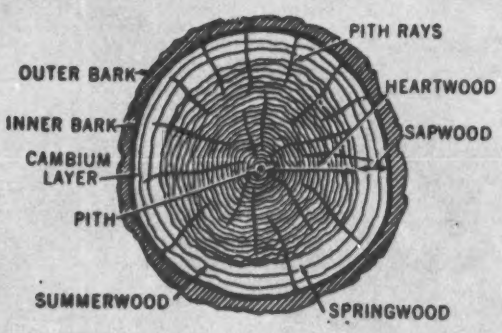

Figure 1. Growth rings in a log.

curing process is speeded by kiln drying, during which time heat is used to lower the moisture content in the lumber. This curing process reduces warping and cupping to some degree. You have learned that quarter-sawed lumber will warp and cup less than plane sawed lumber. Let's find out why.

1-6. The growth rings in a green log are circular in shape by nature. As the log cures and dries out, these circular growth rings try to straighten out. This, along with shrinkage, causes the log to split, or crack, from the center to its outer edge in one or more places. Logs are usually processed at the mill before this splitting takes place. As the logs are sawed, the growth rings become the grain in the individual boards. The portion of the growth rings in any board tends to straighten out as that board cures. Figure 4 shows the end view of a plane-sawed board. You can see how this board will warp, or cup, as the growth rings straighten out during the curing of the board.

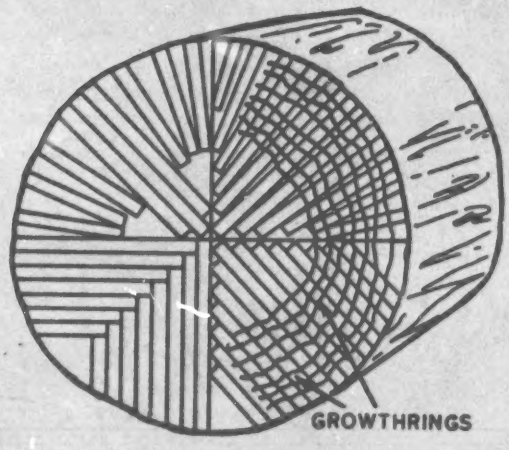

Figure 2. Quarter-sawing a log.

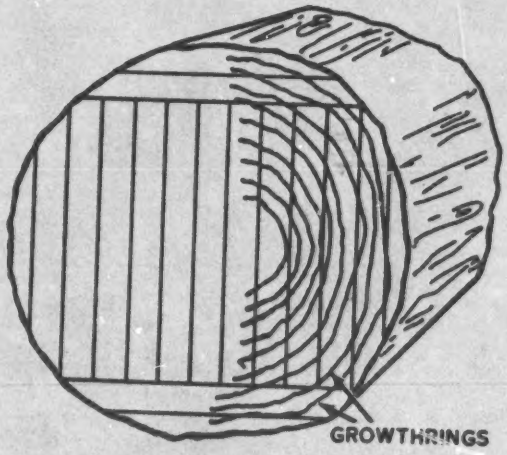

Figure 3. Plane-sawing a log.

1-7. **Groups of Softwoods.** Average shipments of select grades of properly dried softwoods, may be classified as follows with reference to their ability to retain paint and resist weathering. These classifications are listed as follows:

Group 1—Retain paint longest and withstand weathering best.
- Western red cedar
- Other cedars except eastern red cedar
- Southern cypress
- Redwood

Group 2—Retain paint well, if primed, and withstand weathering well.
- Northern white pine
- Western white pine
- Sugar pine

Group 3—Retain paint moderately well and withstand weathering moderately well to poorly.
- White fir
- Hemlock
- Ponderosa pine
- Spruce

Group 4—Retain paint poorly and withstand weathering poorly.
- Douglas fir
- Western larch
- Southern yellow pine
- Norway pine
- Tamarack

Figure 4. Warpage caused by plane-sawing.

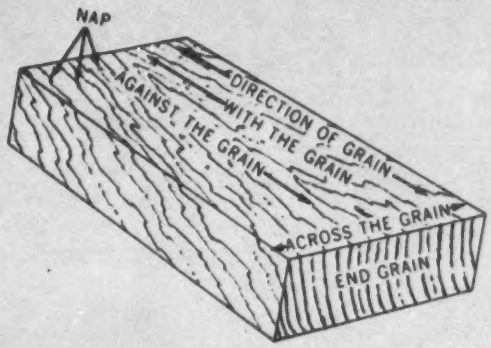

Figure 5. Wood grain terminology.

1-8. **Hardwoods.** Hardwoods are used generally for interior construction. Applications include interior window and door trim, baseboards, moldings, flooring, and cabinet work. Plywood wallboard with an exposed veneer of mahogany, walnut, cherry, or birch are in common use. These hardwoods are normally protected with a transparent or clear finish to enhance their natural color and grain structure. Besides the general wood properties, the size of pores is an important factor in painting and finishing of hardwoods. Hardwoods are used much less than softwoods for exterior building construction because of their poor paintability and weathering characteristics. Hardwoods with pores larger than those in birch, such as ash, chestnut, elm, hickory, oak, and walnut, are unsuitable for ordinary exterior painting. Their use requires an extra operation to fill the pores. Hardwoods with small pores, such as basswood, cottonwood, and poplar, hold paints about as well as the softwoods of group 3. Heavier hardwoods with small pores, such as beach, birch, gum, and maple, hold paint about as well as softwoods of group 4.

1-9. **Description of Wood.** As we continue our study of the preparation and coating of wood surfaces, there will be several terms we will use to describe proper methods of doing a job. During such operations as sanding, scraping, filling pores, and brushing primer or paint, we will use such terms as "with the grain," "against the grain," "across the grain," and "end grain." Very carefully study figure 5. Look at the grain direction and determine its relationship to each of the terms.

1-10. Now that you have learned about the general characteristics of wood, and how they affect painting in general, let's find out how to properly prepare these surfaces for applying the protective coating.

2. Preparation of Exterior Wood Surfaces

2-1. All surfaces to be painted must be clean and dry. They must be free from dirt, oil, and grease. In some cases, old paint in good condition makes an excellent base for repainting and should not be taken off. If the surface to be refinished is checked, cracked, or flaked, then the old paint may need to be removed. You must know how to properly prepare all surfaces before they are painted. You should know that the life and appearance of a good paint job depends on the proper preparation of the surfaces before painting. The serviceable life of a paint job can be reduced by as much as 50 percent by poor surface preparation. You must also realize that the highest quality of coating materials will not stick to a poorly prepared surface.

2-2. **New Construction.** Normally, new lumber and woodwork used in exterior building will require very little preparation for painting. If the surfaces are dirty or contaminated by oil, asphalt, or lumber marking crayon, they should be cleaned with a suitable solvent. Any loose grain or splinters in low grade or poorly manufactured lumber should be removed and the surface made as smooth as practicable. This can usually be done by the use of a hand scraper, scraper plane, or sandpaper.

2-3. *Using scraping tools.* Before using any of the scraping tools to remove bare wood, look at the surface to be worked and determine the direction of the grain. Always scrape or plane in the direction of, and with the grain, and never against the grain. This will prevent the cutting edge of the tool from gouging, digging in, or pulling out chunks of springwood or additional splinters. Remove only enough wood to clear

Figure 6. Knots in painted surface.

the surface of defects. In some cases, removal of excessive wood could weaken the structural strength of the wood.

2-4. *Sanding exterior surfaces.* Probably the most difficult and tiresome job to confront you while preparing surfaces is hand-sanding. It is not customary to sand the entire exterior surface before painting. Exterior sanding should be limited to spot-sanding for the removal of surface defects. On small jobs, you may sand by hand, using a sanding block. On larger projects, you may use a portable disc, or belt sander. Whichever method you choose, always sand in the direction of the wood grain. Do not sand across the grain as the abrasive on the paper will cut deep scratches across the summerwood in the grain. These scratches across the grain are difficult to remove and they will require additional sanding.

2-5. *Removal of pitch.* Any resin or sap spots on the surface should be removed by scraper and sandpaper. When the resin is soft, remove it by cleaning with mineral spirits or turpentine. Pitchy areas may be heated by a blowtorch to encourage bleeding of the resin. Caution should be exercised while using the blowtorch to prevent scorching the adjacent surfaces.

2-6. *Types of knots.* There are two general types of knots found in exterior lumber, and you must know how to properly treat them. One type is a small, tight knot which may have a soft or spongy center. This knot is usually smaller than a nickel. The other type is the larger, hard-center, loose knot. The center of this knot will contain open cracks. Shrinkage of the center may cause it to be loose in the board opening. The grain in the lumber will form a swirl pattern around both types of knots. There will be early discoloration of paint over knots in pine and a loss of gloss over knots in flat grain boards. The effect of knots on paint coatings is shown in figure 6.

2-7. *Treating knots.* Boards which contain loose knots normally will not be found in new construction. The carpenter should saw out sections containing knots before nailing the boards in place. When you do find loose knots, they will require additional treatment. If the center of the knot is loose enough to move in the board, it should be secured by sealing it in place with shellac. If the center is loose enough to rattle, it may be tightened by using a type II calking compound which hardens as it dries. This can be done prior to priming pine, as the center and areas surrounding the knot will contain enough turpentine to allow the calking compound to adhere to the surfaces. Tight knots, which have soft centers, may be filled with calking compound. After the compound has dried, the area surrounding the knot may be smoothed by a hand scraper or sandpaper. Knots should be sealed with a thin coat of knot sealer conforming to Military Specification MIL–S–12935A, Sealer, Surface, Knot, prior to priming. Shellac may be used with some success as a knot sealer, but a sealer which meets the above-mentioned specification is much better than shellac.

2-8. *Repairing small blemishes.* Nail holes and other dents should be puttied after the priming coat of paint has been applied and has dried. All nailheads should be set below the surface with a nail set. The nail hole should be filled

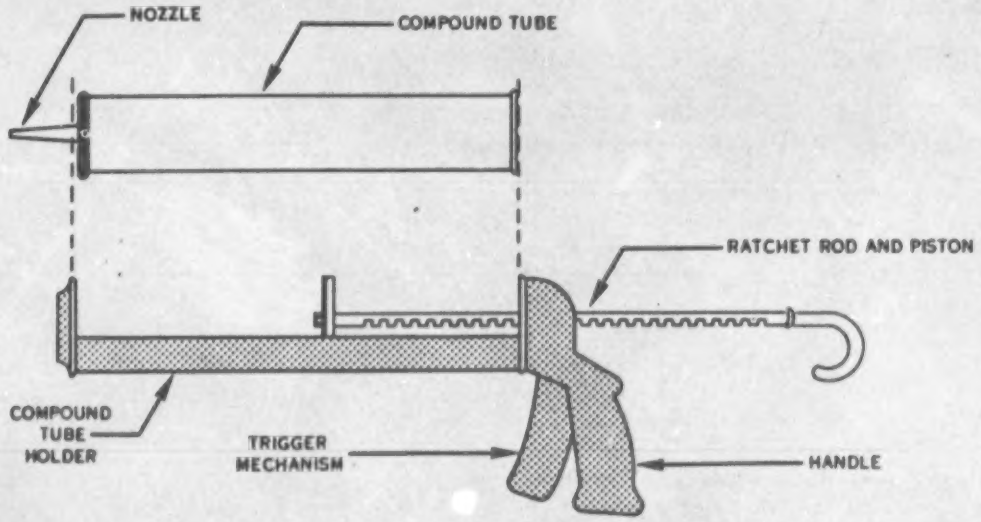

Figure 7. Calking gun.

with putty to completely cover the nailhead. This will prevent rust stains from forming as rainwater runs down the side of a building. Putty comes in either type I or type II. Type I is an elastic glazing compound which dries on the surface but remains slightly soft and plastic underneath. It is recommended for use over nailheads, as it will not have a tendency to "pop out" should the nail loosen in the board. Type II putty hardens as it dries and is used to fill holes and cracks where hard material is desirable. It is used to fill dents, hammer marks, or cracks caused by splintering of the lumber. You can apply putty with a putty knife or by hand. In either case, you must be sure the putty is worked down into the hole or crack. Be sure to remove all excess putty from the surrounding area to leave a clean, smooth surface.

2-9. *Use of calking compounds.* Calking compounds are used to seal cracks and water proof exposed joints around door and window frames in wood construction. You should prime all bare wood surfaces before calking. There are two grades of commercial calking compounds. Grade I is of soft consistency, suitable for application with a calking gun. Grade 2 has the consistency of glazing putty and is applied with a knife. Grade I compound shrinks considerably and sometimes wrinkles. It has the ability to form a tough exterior skin which resists breaking while the underbody remains soft and pliable. Both grades are suitable for use at temperatures above 40° F.

2-10. You should use strands of oakum, calking cotton, or other fibrous materials to form a suitable backstop for filling deep open cracks. Pack to within ¼ inch of exterior surface. This will prevent the excessive use of calking compound. Complete filling the crack with compound, using a knife or a calking gun.

2-11. The standard, hand-operated calking gun (see fig. 7) consists of a compound tube holder, handle, ratchet rod piston, and trigger mechanism. The compound comes in a "throw-away" cardboard tube 10 inches long and 2 inches in diameter. The tube is inserted into the compound tube holder of the gun by rotating the ratchet rod and pulling it all the way back. The ratchet is then reengaged by pushing the rod and piston into the end of the calking tube. Operation of the trigger mechanism exerts force on the piston rod wich causes the piston to eject compound through the nozzle. Place the nozzle tip at or into the joint that is being calked. Cracks often develop in gun-applied compound as a result of bridging the joint which leaves an air pocket behind the compound. To avoid this, you should use a tip small enough to reach the bottom of the joint and hold the gun at an angle which permits you to see that the compound is filling the joint.

2-12. Gun application is recommended for general use. It is easy, economical, and takes about one-third of the time for knife application. Knife application is recommended where a neat finished appearance for some conspicious location is desired.

2-13. After filling joints or cracks, compress and firm the compound against the sides and edges. Press a beading tool against freshly filled joints in order to force the compound into them. Insure that the compound adheres firmly to the back and sides of the crack.

2-14. The final operation of the calking job consists of cleaning compound smears from surfaces adjoining calked areas. Use mineral spirits, or other thinner recommended by the manufacturer of the compound.

2-15. The degree of preparation for painting must depend on several factors. First, consider the grade of lumber used. Next, consider the required life of the structure, and the protective coating to be applied. Other factors which must be considered are cost, time involved, and your own personal safety. For example, you would not expect to give the same degree of surface preparation to a storage shed in a construction yard as you would to a permanent-type office or barracks structure. This is not to be interpreted as lessening the importance of providing a clean, well-prepared surface for painting. Determining the degree to which a given surface must be prepared simply calls for the exercise of good judgment.

2-16. **Previously Coated Wood.** When paint is maintained with a well-planned schedule, the preparation for repainting is easy and inexpensive. Haphazard maintenance, poor choice of paints, or other conditions may result in surfaces which are difficult to prepare for repainting. In extreme cases, it may become necessary to remove all of the old paint before repainting.

2-17. *Stages of paint deterioration.* House paint, for exterior wood, undergoes a slow change from the time it is first applied. You must know what these changes are and be able to recognize them. This knowledge will prevent you from being misled into hasty and unwise early repainting. It will allow you to recognize conditions which warrant repainting to prevent further deterioration. Normal deterioration takes place in six recognizable stages:

a. Soiling. The coating gradually becomes soiled. Dirty paint may be washed but exterior surfaces should never be repainted until de-

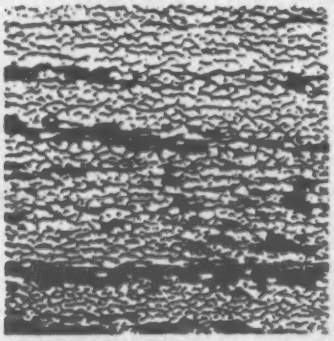

Figure 8. Disintegration by crumbling.

terioration has gone much further than mere soiling.

b. Flatting. The coating gradually loses its initial gloss. It becomes flat, usually within a year on sunny areas but less rapidly on shaded areas. Flatting does not justify repainting.

c. Chalking. The pigment at the surface becomes powdery and may be rubbed off like chalk dust. Dirt will disappear during the chalking stage. On tinted surfaces, the colors appear to fade as the chalking progresses. Normally, exterior paint is in the chalking stage during the greater portion of its useful life. Chalking does not offer sufficient grounds for repainting exterior surfaces.

d. Fissures. Fissures are of two kinds: checking and cracking. In checking, the fissures appear first on the surface but later penetrate entirely through the coating. When checking occurs, it usually begins in 2 years, or well within the first half of the normal life of the paint. In cracking, the fissures pass entirely through the coating. Cracking seldom occurs before the midpoint in paint life, or the beginning of the third year after application. The fissures in cracking are larger and more conspicious than those in checking. Fissures are directly related to the next phase of paint deterioration and the degree of preparation which is required, prior to repainting.

e. Disintegration. The disintegration of paint depends on the type of fissures it develops when passing through the fissure stage. Disintegration develops through crumbling, flaking, or erosion of paint surfaces. Crumbling is an advanced state and is the direct result of checking during the fissure stage. Tiny fragments of coating fall off when the checking penetrates through the coating. The size and shape of the loosened crumbs of paint correspond to the size of the checking pattern. Normally, the paint crumbles from the bands of summerwood much sooner than it does from the springwood, so the grain pattern of the wood is revealed by the disintegration of the paint. Refer to figure 8 and keep in mind the magnified area in the illustration is only ⅛ inch by ½ inch square. The second type of disintegration (flaking) occurs as an aftermath of cracking during the fissure stage. When cracking occurs and leads to curling, the loosened and curled edges of the coating break off. The dimensions of the cracking determine the size of the flaking. Numerous small cracks lead to fine flaking and large cracks to coarse flaking. Fine flaking lays bare summerwood only as it follows the grain pattern of the wood. Coarse flaking, which may properly be called scaling, uncovers both springwood and summerwood at the same time. Flaking paint needs careful preparation for repainting to insure all loose paint is removed. Scaling paint needs still more careful preparation and leaves an uncertain foundation for the new paint. Figure 9 illustrates an area 36 inches by 36 inches square in which deterioration is by flaking and scaling. Repainting should be done soon after the most exposed parts of the building have reached disintegration by flaking or scaling. The third type of disintegration is erosion. Some painted surfaces will not suffer from checking or cracking but will waste away over the years, mainly from chalking. The coating finally becomes too thin to hide the wood and patches of wood begin to be laid bare. The surface usually requires little preparation for painting as there are no scales of loose paint to remove. The surface should be repainted when the coating becomes thin enough to show the grain of the wood while the coating is wet with rain or when patches of bare wood appear.

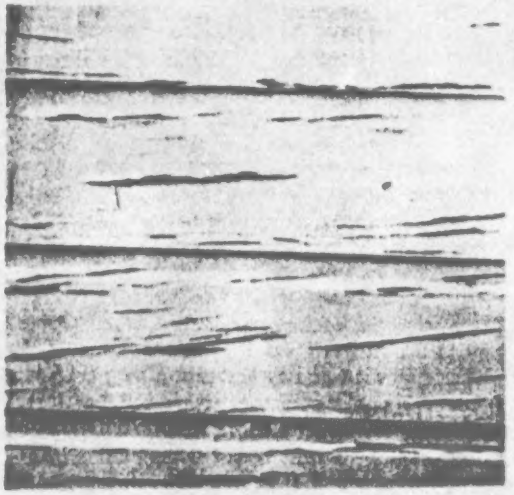

Figure 9. Deterioration by flaking.

f. Advanced Breakup. When disintegration lays bare enough wood for boards to show distress of wood weathering, the coating has reached the stage of advanced breakup. Signs of wood weathering are development of gray color and fine checks, or cracks, in the wood approaching decay. The boards tend to cup and pull loose at their fastenings. Such surfaces are difficult to prepare for repainting and will consume more than normal quantities of paint.

2-18. You have learned the six stages in normal paint deterioration. Now, you must determine how to prepare these surfaces for repainting. As a general rule, the preparation of previously painted surfaces will take much more of your time than the actual application of the new protective coating. Let's consider these surfaces in two groups: those where the removal of old paint is unnecessary and those when old paint must be removed.

2-19. *When removal of old paint is unnecessary.* If there is no loose, curling, or blistered paint, preparation is simple. It consists of seeing that the surface is clean, dry, and free of contamination. Surfaces in the chalking or flatting stage will not be repainted unless a requirement exists to keep them glossy. Should you have need to repaint such surfaces, the preparation consists mainly in cleaning. Wiping with a painter's duster may suffice for most of the area. You may wash very dirty areas, particularly if the dirt is of an oily or greasy nature. Contamination such as asphalt spilled in roof repairs or resin which has bled through the old coating should be removed with scrapers or solvents.

2-20. If there is loose, curling, or blistered paint, you must remove all loose particles with a scraper, wire brush, or sandpaper. The checking or cracking of paint, if there is no loosening or curling at the edges of the fissures, is not considered loose paint. Areas of summerwood laid bare by fine crumbling or flaking of the paint and larger areas of springwood and summerwood laid bare by large pieces blistering or scaling should be hand-sanded. You should sand the area in a manner that will "featheredge" the secure paint into the bare wood areas. If only a few boards on a building are conspicuously worse than the rest in this respect, it may be wise to replace them with boards of more representative density and grain pattern.

2-21. In addition to the normal deterioration stages of protective coatings, there are some abnormal conditions you may encounter. You must know how to prepare these surfaces for repainting.

Figure 10. Surface mildew.

a. Mildew. In warm, damp climates, mildew may appear on exterior painted surfaces. Elsewhere, it may occur as an abnormality in local areas which remain damp for long periods of time (see fig. 10). Mildew is often difficult to distinguish from soiling by dirt. You should inspect any area you suspect to be mildew with a magnifying glass. Mildew is characterized by thread-like mycelia when it is in the growing stage and by numerous egg-shaped spores when it is dry and dormant. Dirt, in contrast, is usually composed of granular particles of irregular size and shape. Since mildew is a fungi growth, mildewed surfaces must be scrubbed clean before repainting or the infection may come through the new paint. You should wash the area with strong soap and warm water. If possible, you should clean the area with a solution of ¼ pound trisodium phosphate to a gallon of water and then rinse the area with clean water. Always wear rubber gloves to protect your hands while using this solution. Mildewed surfaces, which have been properly washed and treated, normally do not require scraping or sanding prior to painting.

b. Discolorations. Occasionally, discolorations appear in painted surfaces. In severe cases they will reappear upon repainting. These discolorations are caused by excessive moisture in the wood. If the conditions which produce the moisture can be changed, the discolorations will not reappear. In extreme cases of faulty or damaged

construction, repairs to prevent the entrance of water or moisture may require the attention of a carpenter, roofer, or plumber. Different kinds of wood will react to continuous moisture to produce different kinds of stains. Reddish-brown to black discoloration of paint on red cedar or redwood occurs when the wood becomes wet under the paint. These woods contain a natural dye which is soluble in water. Pine boards containing streaks of heartwood may develop yellow to brown discoloration beneath the paint. On exterior surfaces the stain usually bleaches out after a few weeks of strong sunshine. The stain may reappear after repainting in damp or wet seasons of the year. A blue to black discoloration which penetrates beneath the coating is blue stain. Blue stain is caused by growth of certain fungi in sapwood. It occurs on windows subject to condensation, at the base of wood columns or posts under which rain seeps, and at joints in railings, stoops, shutters and trim. Since discolorations are caused by moisture, you should seal, or calk, joints and cracks to prevent moisture from getting into or behind boards. Discolored surfaces usually require no additional preparation before painting.

c. Peculiarities of Wood. Economy, or availability, often dictates the use of woods in group 4 for structures that must be kept painted. On such woods, paint in a given stage of deterioration reveals its condition more conspicuously than woods of groups 1 and 2. Look at the surface shown in figure 11. You can see that replacement of the board nearly bare of paint would make the next paint job on this building last much longer with satisfactory appearance.

2-22. You have learned to prepare surfaces of normal deterioration for repainting and how to correct conditions which cause abnormal paint deterioration. Now, let's find out the conditions which require removal of old paint prior to repainting.

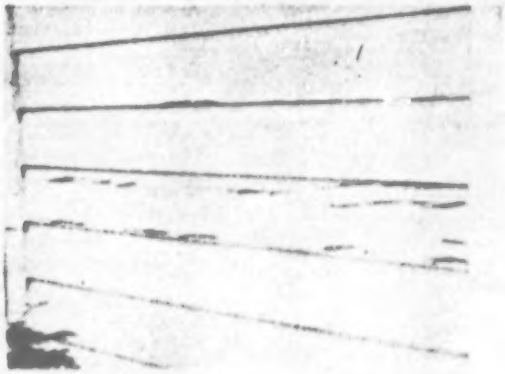

Figure 11. Abnormal deterioration.

2-23. *When old paint must be removed.* Complete removal of old paint is so expensive and time consuming that it is seldom done. In some cases you must do it to get durable repainting with acceptable appearance. Each case must be decided on its own merit, taking into account the price that can be paid for first-class appearance and the estimated future life of the building. The following conditions may justify removal of the old coating:

a. Normal deterioration. Surfaces which have reached the advanced breakup stage of deterioration may be removed. You will find this to be true in the case of old, neglected buildings which suddenly must be refurbished to high standards in appearance. These surfaces normally require a great deal of preparation prior to repainting. It may be faster and cheaper to remove the remnants of the old coating whenever a durable and top-appearance job is specified.

b. Incompatibility between paints. Serious incompatibility between paints may cause alligatoring or wet blistering. The surfaces may remain tacky or be slow drying. The conditions are usually apparent very soon after the protective coating has been applied. They may result from poor painting conditions, practices, or workmanship. The exact cause of these defects will be discussed in Section 3.

c. Coating thickness. Excessive thickness, or an accumulation of many coats of paint, may cause dry blistering and excessive scaling. Coatings more than 10 mils thick may well be removed, and coatings 20 mils or more thick certainly should be removed. You can estimate the thickness of the old coating fairly simply by comparing the edge of a chip of loose paint with the edge of a dollar bill. A dollar bill is 4 to 5 mils thick.

2-24. *Methods of paint removal.* When it is practical to do so, you should remove paint from exterior wood surfaces by wire-brushing, scraping, and sanding. Usually, the old paint sticks too firmly to come off readily by these means. In such cases you must soften the old paint, using either heat or paint remover. You can then scrape the old paint from the surface. Let's learn how to remove paint by using the different methods:

a. Removal by brushing and scraping. You may have success in removing old paint which is chalky or scaling with wire brushes and a hand scraper. In most instances power brushes are more satisfactory to use than hand brushes because less energy is required to use them. Power brushes exert enough circular force on the brush

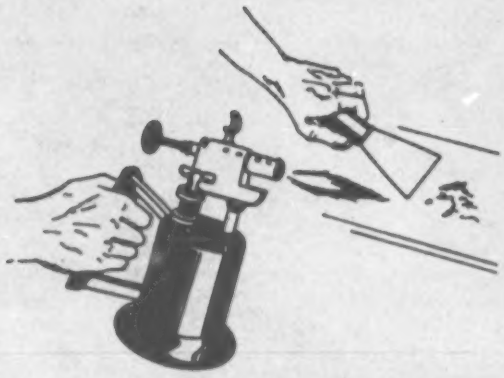

Figure 12. Removal by heat.

to remove stubborn particles which otherwise would be hard to loosen with a hand brush. After brushing the surface, you should use the hand scraper to remove any remaining particles of paint. If hand-brushing must be used, you should alternate the steps of brushing and scraping, brushing and scraping until the surface is clean. When possible, the scraper should be pulled in the direction of, and with, the grain, to prevent digging into the wood. You may complete the job by light, spot-sanding of any rough areas in the surface.

b. Removal by heat and scraping. The use of heat for paint removal is not generally accepted for extremely large wood surfaces. You may use it on small areas where brushing and scraping has failed to remove the coating. Heat is usually applied with a blowtorch. Since the blowtorch produces an open flame and extremely high temperature, you must take care to avoid charring the wood. If charring occurs, the new paint will flatten and deteriorate rapidly. You must also constantly watch to see that the building is not set afire. Badly neglected buildings, on which siding has cupped, may allow the flame from the torch to get into the sheathing or stud space where fire may make headway before it is noticed. You should apply only enough heat to soften the old paint sufficiently for one stroke of the scraper to take off everything down to the bare wood. Do not point or aim the flame at the surface as you would in heating a piece of metal. You should move the torch in a fanning motion; this causes the flame to brush across the surface at an angle. Play the flame on the surface until the paint bubbles and softens, then scrape it off. The scraper should follow the flame at a distance of about 2 inches. You may prefer to use a putty knife rather than the hand scraper on some surfaces. The proper method of using a blowtorch and putty knife to remove paint from a wooden surface is shown in figure 12.

c. Removal by solvents and scraping. Paint remover is a mixture of solvents which will soften old coatings of paint, varnish, lacquer, and shellac. After the old coatings have been softened, you can remove them with a hand scraper or a putty knife (see fig. 13). Paint remover comes in either liquid or paste form. Liquid remover dries rapidly, and for that reason, is used on small areas at a time. Paste remover remains moist for a considerable length of time and can be used on larger areas. The paste form is generally used on exterior walls because you can apply it easily to the vertical surfaces without it flowing off. You should apply the paste with a soft brush, using a mopping-type stroke. The paste should be applied across the boards and grain first. This will work the remover under the edges of the old coating along the strips of summerwood, and into the crevices between the boards. You should then smooth the paste in the direction of the boards or grain, redipping the brush into the paste if necessary to insure a generous, even covering by the remover. Do not brush more than is necessary as overbrushing causes evaporation of the liquids in the paste and slows the softening action. When liquid paint remover is used for small areas, you should brush it on freely in the direction of the board or grain only. In this manner a wax forms a leafed coat-

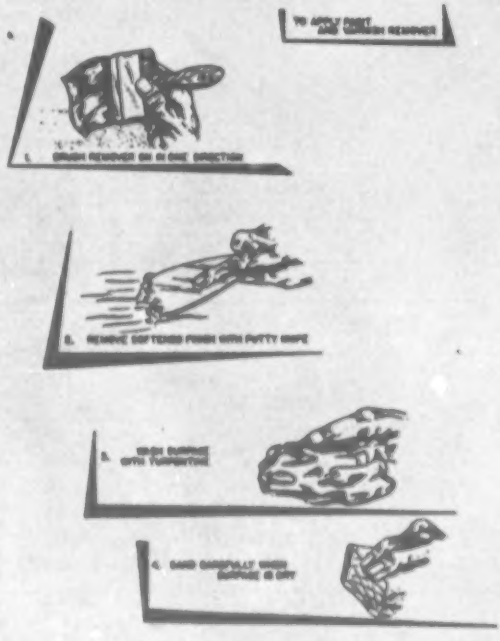

Figure 13. Removal using solvents.

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ing over the old surface and slows evaporation. This allows the active ingredients in the remover more time to act. Brushing the remover back and forth destroys this leafing action and reduces the effectiveness of the remover. With either paste or liquid remover, the softening action should be allowed to continue until one stroke of the scraper will take off everything down to the bare wood. Ordinarily, a clean, wood surface, entirely free from old paint should be left. The bared surface should be washed with paint thinner and wiped dry with a cloth to remove any wax left by the remover.

2-25. Be extremely cautious when using paint removers. Most of them are highly flammable and some are toxic. Do not allow the brush to flick small particles of the remover into your eyes, face, or onto your skin. The strong chemicals in the remover may cause superficial skin burns.

2-26. When scraping off the old paint, deposit the residue from the scraper in an old bucket or container. Do not clean the scraper after each stroke by slinging or throwing the residue into the surrounding grass or shrubbery. The chemicals in the remover may burn or destroy the foliage.

2-27. Regardless of the method you use to remove paint, you will probably need to spot-sand small areas. You should use a sanding block and sheet paper for this operation. You may have some success using a rotary disc power sander, but you should avoid cutting deep scratches across the grain, which may show through the new coating. Never attempt to remove an old, thick coating by power-sanding alone. The heat buildup between the abrasive and the paint surface will cause old paint to stick and form a glaze on the abrasive paper. Continued use of a belt sander under these conditions will cause additional heat buildup and destroy the belt. A good rule to follow is: Use heat or solvents to remove paint and use power sanders to smooth wood.

2-28. You should complete the surface preparation by inspecting and repairing any small defects. Reset any loose nails and fill all holes, dents, and cracks. Inspect windows and doors for broken glass and missing or damaged glazing compound.

2-29. *Replacing glazing compound.* The replacement of glass and glazing compound requires a great deal of skill as well as knowledge. The skill can only be developed through practice. When any portion of old putty (glazing compound) is missing or loose, all of the putty should be removed. The better job you do in scraping the putty from the sash, the easier you can apply the new compound. When the putty runs are clean, you should brush their surfaces with mineral spirits or turpentine. This will cause the new putty to stick to the wood. When glass must be replaced, the new pane should be sized to fit into the rabbet with about $\frac{1}{16}$ inch clearance at each edge. This will provide space for bed putty to form a cushion completely around the pane. Either of two types of glazier points may be used to secure the glass into the rabbets. You can drive the triangular-shaped ones with a hammer and the edge of a screwdriver. You may need a special gun to drive the diamond-shaped type. Each type must be driven so deep that they will be completely covered after the putty is applied. To properly apply the putty, place a continuous bead along the glass face and putty run. This is illustrated in figure 14. You can prepare the putty roll by rolling putty back and forth between the palms of your hands. You complete the glazing operation by pressing the putty into place with a putty knife. Use enough pressure to insure that the putty will adhere to the glass and sash. Finish the surface with a full, smooth stroke of the knife. Form a neat, straight bevel with clean-cut miters at the corners. Trim any bed putty which pushes out on the reverse side of the glass.

2-30. New construction should be painted or at least prime-coated, as soon as possible after erection. Old surfaces which have been cleaned and prepared should be repainted as soon as practicable as a precaution against deterioration of the prepared surfaces. You have learned how to prepare exterior wood surfaces for painting; now, let's discuss the proper methods for applying protective coatings.

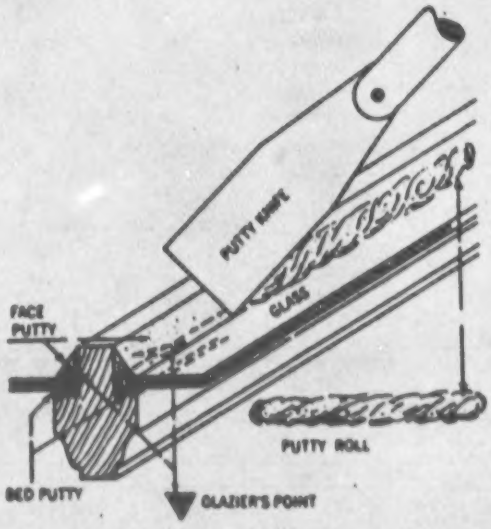

Figure 14. Applying glazing compound.

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3. Applying Protective Coating to Exterior Wood Surfaces

3-1. To be a top painter, you must have a great knowledge about the entire operation. Practice plus experience will develop your skill in using a brush or spray gun. This skill is important to the beauty and durability of the job. In addition, there are other factors which you must consider.

3-2. **Atmospheric Conditions.** In northern latitudes, exterior painting should be done during the warm part of the year. In southern latitudes, the local rainy season should be avoided. There will be times when exterior painting must be done in weather not ideal for painting. The chief hazards are rain, dew, frost striking fresh paint, or a sharp drop in temperature while paint is drying. The defects which may result are slow drying, wrinkling, and uneven gloss.

3-3. **Time for Drying Between Coats.** In dry air at 70° F. or above, you should allow exterior paint to dry at least 48 hours before recoating. Dampness or low temperature may delay drying for an additional day or two. You should apply the next coat as soon as possible after the undercoat is dry. Delay of more than a week between coats should be avoided. New construction finished in winter, presents a different problem. The exterior wood cannot go unprotected through the winter because its surface will roughen. You can apply a priming coat in winter but it will offer little protection. By the time spring comes, it may not be in the best condition for recoating. You should complete the exterior painting as promptly as the hazards of winter will permit.

3-4. **Priming of Exterior Wood.** The durability of protective coatings depends greatly on the proper priming of the surface. There are three types of priming operations: "spot priming," "full priming," or "spot priming followed by full priming." Varying conditions of the surface will determine which priming operation you use. The following information will give you a knowledge of the different priming operations:

a. Spot priming. Spot priming may be considered as a touchup operation. Small defects such as knots, resin leakage, or small areas of flaking and scaling may be spot-primed. You should spot-prime individual bad boards or any new boards which replace old ones. As a general rule, you will spot-prime only those buildings on which the paint is less than 2 years old.

b. Full priming. Full priming means the entire surface must receive a priming coat. You will always full-prime new construction or surfaces from which the old coating has been removed. You should full-prime old surfaces where the old paint is checking or cracking over the entire area.

c. Spot priming followed by full priming. Spot priming followed by full priming is a combination of the two operations. You will normally use this method on buildings where the paint is more than 2 years old. When the old paint is disintegrating, you should remove the loose paint and spot-prime the areas affected. After the spot priming has dried, follow with a full priming coat over the entire surface.

3-5. **Number of Coats Used.** On some jobs the total number of coats of paint to be applied will be specified. On other jobs you must determine the type and number of coats needed. It is accepted practice in the painting trade to describe painting coverage as one coat, two-coat, or three-coat systems. The number of coats to be applied, including primer, will determine the total thickness of the coating. On exterior woodwork, a thickness of 4 to 5 mils is desired. Paints, which meet Federal specifications, are designed to build 4 or 5 mils thickness with two heavy coats, or with three lighter ones, provided the spreading rate is gaged correctly. The following information should help you determine the coverage required for any surface:

a. One-coat. Buildings on which the paint is not curling or scaling, and which do not need priming, usually need only one coat of finish paint. One coat provides ample coverage if there is at least 3 mils' thickness of old coating left on the surface. If there are scattered patches of flaking or scaling which expose bare wood, you should spot-prime the bare places and then apply one finish coat of paint over the entire surface.

b. Two-coat. When the old coating is less than 3 mils' thick, two coats of new paint are usually needed. When there is enough flaking and scaling to expose some bare wood on all parts of the wall, two coats should be used. The first coat generally should be primer and the second coat will be finish paint.

c. Three-coat. For painting new wood surfaces or those from which all old paint has been removed, you should use three coats. On new wood, the first coat should be primer and the last two coats finish paint. The second coat (first coat of finish paint) should be thinned moderately before application. Apply the third or final coat as it comes in the can. On bare surfaces to be repainted, you may use priming paint for the first two coats and finish paint for the last coat. In either of the three-coat systems, the spreading rate should be gaged to give a total coating thickness of 4 to 5 mils.

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3-6. You have learned that the number of coats to be applied should be governed by the thickness of the old coating and its condition. When repainting, the addition of new paint should not bring the total thickness too much over 6 mils. The thicker the old coating, the less new paint should be added.

3-7. The initial appearance of the repaint job will be affected when the one coat system is used. The paint may dry with less than its full degree of gloss. It may vary in gloss according to the texture of the old paint under it. It may show flat spots over the flaking or cracks in the old paint. These are all minor blemishes. They will disappear as soon as the new paint reaches the chalking stage.

3-8. **Poor Painting Technique.** Poor painting technique may cause a newly painted surface to be unsatisfactory and unacceptable. These conditions must be corrected before further painting is done. Poor or bad paint, as it comes from the factory, is seldom responsible. Paints which conform to Federal specifications are high-quality products suitable for their intended uses. Poor workmanship is seldom responsible, but it can add to the problem. A lack of knowledge on your part can cause you much grief when you are applying paints. It is always safest to repaint surfaces with the same type paint used before. You should use only recommended combinations of primers and finish paints. Use of dissimilar paints may cause the following defects:

a. Lifting. Lifting is a softening of the old paint by strong solvents in the new coating. For example, some rubber-base paints contain solvents used in paint removers, and are incompatible to many oil base paints.

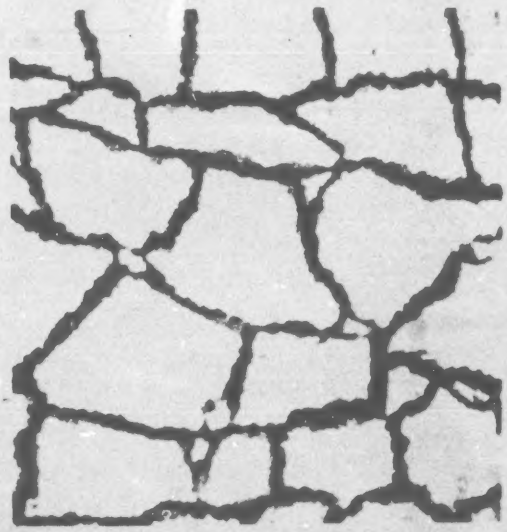

Figure 15. Alligatoring on surface.

Figure 16. Wrinkling on surface.

b. Crawling. Crawling occurs when the new coating fails to wet the surface of the old paint. The new coating will collect in drops as water does on a greasy surface.

c. Tackiness. Tackiness may occur if the new coating is applied in damp air or cold temperature. Failure to use paint remover to remove wax left on surfaces is likely to slow or prevent drying of a new coating.

d. Alligatoring. In alligatoring, the newly applied paint cracks and slips over the old coating so the old coating can be seen through the fissures. Alligatoring is caused by the application of dissimilar paint over the old coating. This condition is illustrated in figure 15.

3-9. Typical coating combinations that cause alligatoring are:

a. House paint applied over bituminous paint or roofing tar.

b. Painting over deposits of pitch or over shellac on knots.

c. Paint or enamel applied over varnish.

d. Light colored house paint applied over heavy coatings of darker color.

3-10. Wrinkling is a drawing up of the new coating into ridges while the paint is drying. It may vary from a bold to a fine pattern which appears to be loss of gloss (see fig. 16). Wrinkling can occur at any time if paint is applied in unduly thick coatings. It occurs most often when

there is a drop in temperature of more than 20° F. within a few hours after the coating has been applied.

3-11. You should have learned some of the factors which affect the durability and appearance of an exterior paint job. Now, let's discuss the actual procedures for applying the protective coating to the surface.

3-12. **Application of Exterior Coating.** You can apply protective coatings to exterior wood surfaces either by brush or spray. Each of the methods has its advantages and disadvantages. You can usually paint more neatly by the brush method than with spray guns. Spraying of paint requires troublesome masking. It produces mist and overspray. You can gage the spreading rate of the paint more easily when brushing, because you are guided by feel, sight, and length and drag of the brush strokes. When spray-painting, you must rely entirely on sight and timing. You can do a better job with a brush in depositing extra paint in the hollows without overloading the high spots. On the other hand, you can reach wide, deep cavities with the spray that a brush cannot enter. After you become skilled in the use of the spray gun, you can paint wood as well as the best brush hands can do. Most top painters still agree and recommend that the first prime coat on wood should be brushed on. The primer adheres tighter when it is brushed and cross-brushed into the pores of the wood.

3-13. *Spraying exterior wood surfaces.* You may save labor by spray-painting buildings which have large wall areas unbroken by windows and doors. Buildings with many windows and doors offer less chance to save labor, especially if they are trimmed in another color. Spraying ordinary dwellings offers little economy unless the following short cuts are acceptable:

a. Use only one color and type of paint for walls and trim.

b. Cover all glass with masking compound and spray over sash and glass.

c. Strip the dried paint and masking compound from the glass.

3-14. Instructions for actual use of the spray gun will be covered in Chapter 3. Since you will be using the brush method to paint most exterior wood surfaces, let's discuss the proper use of the brush in applying paint.

3-15. *Brushing exterior wood surfaces.* You will probably use a 4-inch brush for painting exterior walls. Make sure the brush is clean and remove all loose bristles. Check your paint for proper mixing and box it if necessary. Dip the brush about 2 inches into the paint several times. This will work the paint into and load the brush. Each time you load the brush, tap the tip of the bristles against the inside of the container. This will remove any excess paint from the brush. As you move the brush from the paint container to the work, keep the bristles pointed downward. This will prevent paint from running into the metal ferrule and down the handle of the brush. Apply the paint to the surface in two or three places, as shown in figure 17,A. Next, feather the paint as shown in B. You then finish by using long strokes, as shown in C.

3-16. Hold the brush lightly but firmly. The paint should be brushed to a uniform film of desired thickness. You should brush oil paints thoroughly to coat all defects in the surface. Rapid-drying paints should be brushed only enough to spread the paint and avoid excessive thickness.

3-17. Do not poke or jab the brush into corners or cracks. This will damage or break the bristles. When applying primer to large knots, you should first move the brush in a series of small circles to completely cover the area. The finish paint should be applied by using long, parallel strokes.

3-18. The second and third coats of paint should be applied in long strokes. You will get better results by painting in a series of 2- to 3-

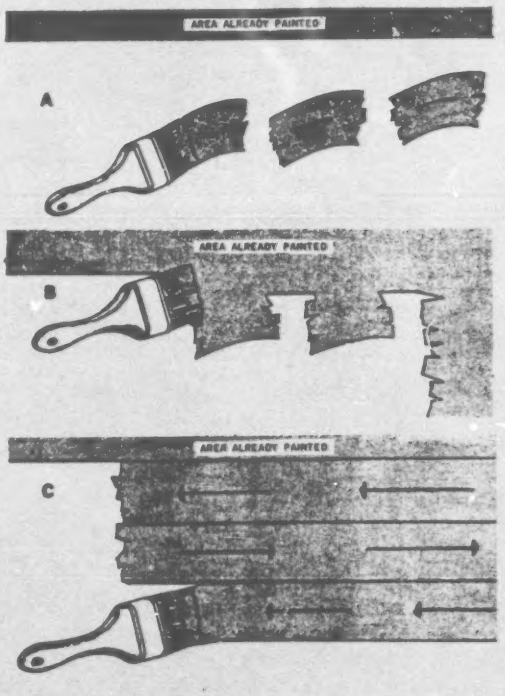

Figure 17. Brushing paint.

foot strips along the width or length of the building. You should always start the painting at the top of the area and work down.

3-19. *Painting exterior equipment.* You will find the painting of exterior trim, windows, doors, and other equipment to be time consuming. More patience and skill are demanded while painting these objects. You must be able to cut straight lines and edges with the brush. Since trim is generally painted after the body of the building, you must avoid drips, spills, or splatters. Even if the trim is to be painted in a different color, you should prime it at the time the walls are primed.

3-20. *Painting exterior trim.* You will probably select a 2- or 3-inch flat brush for painting exterior trim. Door facings, window facings, corner boards, and trim and mouldings, on or around eaves should be primed to a thickness which will require only one coat of finish paint. You should apply the finish paint in the direction of the grain. When using outside enamel or any fast-drying paint, brush only enough to smooth the paint and prevent runs. You should avoid rebrushing over the newly painted areas which have already become tacky.

3-21. *Painting window sash.* Window sash should be painted at the time the facings and jambs are painted unless they are to be a different color. Single-pane sashs are simple to paint. Sashs which have many separated panes of glass require more patience. You may select either a ½- or ¾-inch oval sash brush for the job. When painting double-hung windows (see fig. 18), the sash should be positioned for painting. Pull the top sash down slightly and raise the lower sash. This will allow you to paint the top rail, bottom rail, and the inside of the meeting rails. You can then reposition the sashes to paint the stiles, muntin, and mullion rails. The paint should completely cover all glazing compound to form a seal between the compound and the pane. When you have several windows to paint, you may want to use a straightedge guide. You can make a guide from an old metal venetian blind slat. Cut it to length and place one edge on a line where the glazing compound joins the glass. You can then paint the rail with one smooth stroke of the brush. Wipe the paint from the guide with a rag, being careful not to cut your fingers on the sharp edge. Repeat the process until all rails are painted.

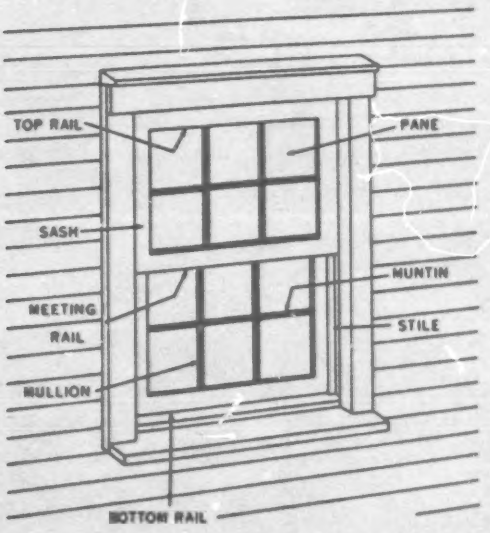

Figure 18. Window terminology.

Figure 19. Spray-painting window screens.

3-22. *Painting wooden screens.* Before painting window and door screens, you should remove dirt and rust. You can do this by brushing the screen cloth with a stiff-bristle scrub brush. The type of paint you use will vary with the type of screen cloth. Black enamel is used on black iron or galvanized screen cloth. Spar varnish is used on copper or bronze screen. Screens with aluminum frames and aluminum screen cloth should not be painted. You should paint wooden frames which have been exposed less than 2 years with only one coat of finish paint. On screens which have been exposed more than 2 years, you should apply one coat of primer and one finish coat. When many screens must be painted, you may save much time by spray-painting them, as shown in figure 19. Stack the screens on saw-

horses. Spray the top screen and remove it from the stack. Spray the next one and remove it. Continue this process until all screens are painted. The spray mist from the top screens will filter down through the stack as you paint. The screens near the bottom will require less spraying. Enamel used for spraying screen cloth should be thinned with one pint of mineral spirits to one gallon of enamel. You should be very careful not to overspray screen cloth. Too much paint will fill the openings in the screen. When spray equipment is not available, you can paint screen cloth with a wood block, approximately 2 x 4 x 6 inches, covered with floor carpet. Dip the block into a pan containing the paint and apply it to the screen.

3-23. *Painting exterior floors.* Exterior wood steps, platforms, and floors of open porches must stand heavy traffic. You should use a porch and deck paint which hardens more rapidly than house paints for these areas. As a rule, these paints are worn out by the pounding of traffic rather than the slower action of weather. For this reason, priming coats add little to the life of the surface. The paint can be used as its own primer. After several repaintings, porch and deck paint may reach a condition of breakdown on the less trafficked areas. In this case, you may completely remove the old paint before repainting. Porch and deck paints are normally applied with a brush.

3-24. *Painting shingles and rough-sawed lumber.* The rough surfaces of wood shingles, or boards with unplaned surfaces, are expensive to paint. They absorb excessive quantities of paint and still dry flat. Such surfaces are usually coated for appearance rather than durability. When you are interested only in durability, you can brush or mop the surface with hot linseed oil. If the surface is being coated for appearance, you should use an exterior wood stain. You should always apply two coats of stain because of the high vehicle content. If only one coat is used, the vehicle solids are absorbed, leaving little binder to hold the pigment on the surface. The pigment will then wash away easily. Shingle stains are available in red and green colors. Other exterior stains are available in a redwood color or brown. If you need a stain to match a color of house or trim paint, you can mix it on the job. Mix two parts of staining oil with one part of the house or trim paint. If the staining oil is not available, paint thinner may be substituted. You will normally apply stain with a brush. You should overbrush all runs immediately as you apply the stain. The spreading rate is low, often no more than 100 square feet per gallon, depending on the roughness of the wood. When mixing stains, make sure you have enough stain to complete the job.

3-25. *Painting creosoted wood.* Creosote leaves wood with a surface difficult to paint. It may sometimes be desired to paint the upper parts of creosoted posts set in the ground. Most oil paints or enamels will soon become discolored by creosote from the wood, and the surface may alligator. Two coats of exterior aluminum paint will make a bright coating that resists discoloring as the creosote bleeds. The aluminum paint remains bright because the aluminum particles float on top of the paint vehicle. You should not apply white oil paint over the aluminum as it may still result in discoloration. If the creosote surface is old and weathered, or has rough surfaces, you may paint it white by using a water-thinned paint. You may use a casein paint, exterior latex, or even ordinary whitewash. A reasonable degree of whiteness may be retained for as much as 2 years before repainting is necessary.

3-26. We have discussed many aspects of the preparation and coating of exterior wood surfaces. Now, let's see what we can learn about the preparation and coating of interior wood surfaces.

4. Preparation and Coating of Interior Wood Surfaces

4-1. There are two primary reasons why interior wood surfaces are painted. The first is for appearance and the second is for cleanliness and sanitary reasons. Interior wood surfaces will remain sound for years without a protective coating, since they are not exposed to weather. Exceptions are shower rooms, utility rooms, and kitchens where the surface is exposed to excessive moisture. Coated surfaces are easy to clean and they resist the buildup of odor and germ-bearing dirt.

4-2. Interior wood surfaces usually require a higher degree of preparation than exterior surfaces. Some wood paneling used in modern interiors has a transparent finish. This finish acts as a magnifying glass to bring out the quality and color of the grain. It magnifies the mill marks, checks, dents, and scratches on the surface. The use of opaque paint on wood surfaces may cover a large number of imperfections; but even these surfaces must be well prepared. You should never use exterior house paint on interior wooden surfaces because exterior paint may dry slowly, may never harden as much as desired, and may gradually turn yellow.

4-3. **Preparing and Coating Surfaces with Opaque Coatings.** New interior surfaces installed with top workmanship by the carpenter will require less perparation before application of

opaque coatings. You should remove planing marks, hammer marks, and raised grain by sanding. After application of the priming coat, you should fill all nail holes, cracks, and other defects with white-lead, whiting putty. After the putty has dried, spot-sand the surface. The prime coat should approximate the color of the finish coat to be used. Three standard types of finish paints are provided for interior use. You should select the right one for the job according to the degree of gloss and washability desired. The following information will aid you in selecting the proper paint for a particular job.

a. Flat-finish paint. This is a paint which dries with little gloss, to give a so-called eggshell surface. For large areas, such as plywood panels on walls and ceilings, flat paint presents the most pleasing appearance. It provides a comfortable distribution of light. This paint may be washed occasionally to keep it clean. It will not stand as many or such vigorous washings as the paints described below.

b. Semigloss-finish paint. Semigloss paint is an enamel made with a varnish vehicle and a high level of pigments. It produces a semigloss appearance and is a coating which stands wear and washing well. It is generally used for walls and ceilings in service rooms, such as kitchens and bathrooms. Here, good washability is important and moderate gloss surfaces are customary. Semigloss paint should be used for window and door trim and for baseboards even when flat finish paint is used on walls and ceilings.

c. Gloss-finish paint. Gloss paint is an enamel with good hiding power. It has a moderate level of total pigment in a varnish vehicle. It produces a high-gloss surface which washes well. It is considered to be a high-priced interior finish because of the surface preparation needed for its application. The high-gloss coating accentuates all defects in the surface. The surface preparation should include a second priming coat which has been sanded smooth.

4-4. Opaque paints may be applied to walls and ceilings by brush, spray gun, or roller. The method of application selected is governed by the particular job. Interior enamels are self-leveling and very suitable for brushing; but brush application is slow. Spraying inside small rooms presents a ventilation problem, a great fire hazard, and requires masking of areas and protection from overspray on floors. The use of a roller coater is reasonably fast but will usually require two coats for consistent color coverage; also, additional use of a brush is required to cut in corners and paint around trim.

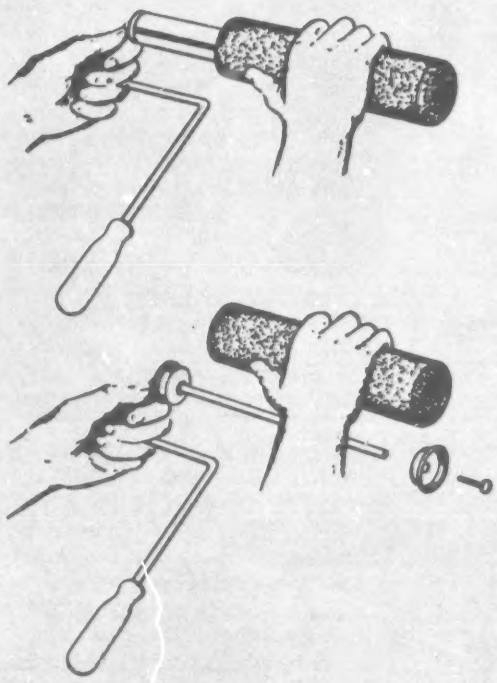

Figure 20. Removing roller coater covers.

4-5. Paints on interior surfaces do not wear away appreciably between paintings. They will eventually build up too much thickness of coating. Interior painting should always be done with the minimum number of coats and maximum spreading rate consistent with good appearance.

4-6. *Painting plasterboard.* Dry-wall construction, in which plasterboard instead of wet plaster is used, is very popular in modern frame construction. Joints in the plasterboard are taped and bedded with a special joint compound and then sanded smooth. A stipple finish may be applied to plasterboard to produce a surface similar in appearance to plaster. Complete details on taping and bedding plasterboard will be covered in Chapter 2. Paint plasterboard surfaces in the same manner as interior wood surfaces. When plasterboard is used in damp areas, apply one coat of primer sealer followed by one coat of enamel undercoat or primer. Plasterboard is more generally painted with self-priming, interior latex paints. These paints dry rapidly and are applied with a roller coater.

4-7. *Applying paint with the roller coater.* You have learned the types and sizes of roller coaters. You will probably select either a lamb's wool or mohair cover for painting interior surfaces. The roller unit is constructed so that the cover can be removed or changed. Figure

20 shows two types of roller units. Note the cover simply slips on and off one type, while the other must be disassembled to allow removal of the cover. You will also need a roller coater pan wide enough to accommodate the roller. Even though most of the painting will be done with a roller, you need a 2- or 3-inch flat brush to apply a strip of paint along the edges and corners of the area to be painted, as shown in figure 21. Cut in one area at a time with the brush, then follow immediately with the roller on the remaining surface to avoid lap marks. When both ceiling and walls are to be painted, always paint the ceiling first. Use the same procedure for painting both ceiling and walls, except a long handle roller should be used for the ceiling. Place the roller pan on the floor, partially fill it with paint,

Figure 21. Edging surfaces with brush.

dip the roller into the pan, and squeeze it against the bottom with a rolling motion. Now, apply the roller to the ceiling and make several crisscross strokes. This distributes the paint and insures coverage on stippled surfaces. Work quickly but not too fast because paint will sling off the roller if it spins too rapidly. Finish the rolling with long, parallel strokes in one direction. Start at one edge of the ceiling and work your way across the room. You should paint the walls with a short handle roller. Place the paint pan on the ladder shelf. Use the same procedure for painting the walls that you use for painting the ceiling. Figure 22 shows the correct way to apply paint in crisscross strokes. Figure 23 shows how to finish the rolling by using long, parallel strokes. If the painting is interrupted before completion,

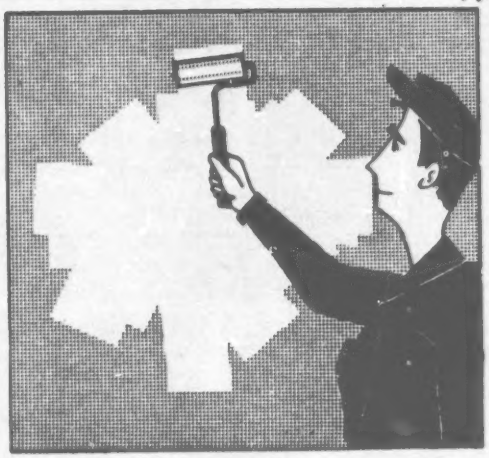

Figure 22. Painting crisscross with roller.

stop at a joint in the construction or in a corner of the room. Avoid applying paint over the edge of paint already set because this may cause unsightly lap marks. If you notice thin spots, go over that portion again. These thin spots or any spots which have been missed are called *holidays*. When repairing holidays, always finish the rolling with long, parallel strokes. If a second coat is

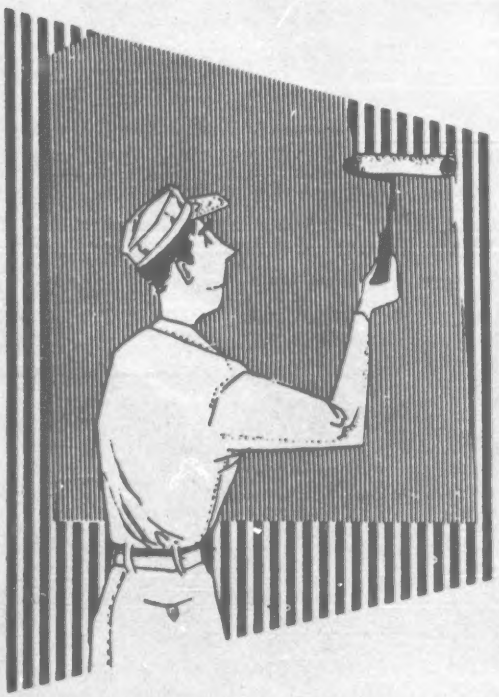

Figure 23. Painting parallel strokes with roller.

required, apply it in the same manner as the first, starting with the ceiling.

4-8. *Repainting old opaque surfaces.* The degree of surface preparation for wood surfaces to be repainted will vary. Surfaces with no damage other than normal deterioration require little preparation. You should clean the surface by dusting and removing all dirt. If the surface is badly soiled with dirt of a greasy nature, such as in kitchens, the surface should be washed thoroughly before refinishing. You may use a good detergent soap and water to clean these areas. Any damaged spots, where coating has been scratched or has worn through to the wood, should be primed. You should spot-sand these areas after the primer has dried. Unless colors are changed, satisfactory coverage can be obtained with one coat of finish paint. Door, window, and baseboard trim should be sanded lightly and have one coat of trim enamel applied.

4-9. Plasterboard walls should be dusted thoroughly before repainting. Dust adheres readily to stippled surfaces. You can clean these surfaces with a vacuum cleaner and brush attachment. All cracks in the plasterboard must be repaired before repainting. If you paint over these cracks without repairing them properly, the crack will reappear when the new coating dries. Repair such cracks by taping and bedding, using the following procedure:

a. Obtain a clean container and mix a suitable amount of plasterboard joint compound. Follow manufacturer's directions for mixing and allow the mixture to set for 20 to 30 minutes prior to use.

b. Use a 2 x 4-inch sanding block and medium grit paper to remove the stipple and old coating along the full length of the crack. Remove everything down to the paper surface for a distance of 2 inches on each side of the crack. Feather-sand the edge of the stippled area into the bare surface.

c. Restir the joint compound to an even consistency. Use a 4-inch-wide putty knife to apply the joint compound over the crack. Spread the compound to a thickness of $\frac{1}{16}$ inch for a distance of 1½ inches on each side of the crack.

d. Tear a strip of perforated, joint tape from the roll. The tape should be long enough to cover the crack without splicing. Use a wide blade putty knife to imbed the tape into the compound. The tape should be aligned so that the crack falls near the centerline of the tape. Place the knife across and near one end of the tape. Hold that end of the tape in place with one hand and pull the knife along the tape with the other hand. Apply enough pressure on the knife to imbed the tape into the compound with no wrinkles in, or bubbles under, the tape. Use the putty knife to remove all excess compound from the area. The tape should be visible in the compound at this point. If time permits, allow the tape and compound to dry several hours before proceeding to the next step.

e. Use the putty knife to apply a layer of joint compound over the tape. Compound can be kept for several days if the container is covered with a wet rag. Spread the compound so the center and edges of the tape are completely covered. Feather the compound into the edge of the old coating by using the flat side of the putty knife as a trowell. Use long, even strokes of the blade along the length of the tape. Do not use short strokes across the tape, as this tends to raise and curl the edge of the tape. Allow the compound to dry thoroughly.

f. Hand-sand the compound very lightly. Remove all trowell marks so the surface is smooth and blends into the old coating. Be careful not to sand through the compound into the tape. Apply the stipple to the repaired area by using a sponge. Dip a wet sponge into the joint compound and pat lightly over the repaired area. With a little effort, the pattern in the old coating can be duplicated. Allow the stipple to dry and the repair is complete.

4-10. Repair any other areas where the stipple has been damaged. Desks or tables placed against walls may rub through the coating and leave the plasterboard exposed. If you fail to repair those areas, the new coating will dry flat. Apply new stipple to these areas with a sponge.

4-11. After all repairs are complete and the surface has been cleaned, you can apply the new coating. When enamel is used as the finish coat, prime all repaired areas with an enamel undercoat and allow it to dry. When interior latex paint is used, spot-prime the repaired areas with the latex paint first and then proceed immediately to apply the finish coat. Repainting of plasterboard surfaces should be done by following the same procedure as for new work.

4-12. **Preparing and Coating Surfaces With Transparent Coatings.** Interior walls and ceilings that are to receive transparent finishes must be constructed from top-quality materials. Number 1 grade, clear, fir plywood, or mahogany-veneered plywood, make attractive walls for offices in warehouse or shop areas. These materials are reasonably cheap and easy to obtain. Cherry, walnut, or birch-veneered plywood, or plank paneling may be used in high-priority executive offices. These materials usually come with a factory-applied finish.

4-13. To prepare new surfaces for transparent finishes, sand the woodwork to remove all marks and blemishes. Be very careful when sanding a veneer surface on plywood. Do not sand through the veneer covering into the center ply of the board. Use either a sanding block or a small vibrating sander for this operation. Never use a belt or rotary power sander. All sanding should be done in the general direction of the grain.

4-14. *Staining interior surfaces.* It is often desirable to stain interior wood surfaces before applying transparent finishes. Fir plywood used for ceiling and wall panels is generally stained with either light- or dark-oak oil stain. This adds body and richness to the finish. Even for surfaces which have a factory finish, you will probably have to stain window, door, and base trim to match the color of the panels. This trim may be either softwood or hardwood. You may mix these stains on the job, using the formula given in Memorandum 562, figure 35.

4-15. When staining softwood, you apply pigment oil stain directly to the bare wood. For darker colors, such as walnut, you may first brush on one coat of sealer or one thin coat of shellac. Use steel wool to remove the sealer or shellac until the surface has the appearance of bare wood. You then apply the oil stain by brush and wipe it off with rags. The longer you let the stain set before wiping, the darker the tone will be. Always wipe off all excess residue before the stain dries. If you want darker tones, apply another coat.

4-16. To stain hardwoods with pores smaller than those in birch, use pigment oil stains in the same manner as on softwoods. It is seldom desirable to apply sealer or shellac to hardwoods before staining. Hardwoods with larger pores are finished in a similar manner, except pores must be filled with a wood filler before staining. A paste filler is generally used for ceiling, wall surfaces, and trim. You should apply the filler vigorously across the grain and allow it to set from 10 to 30 minutes. Remove the excess filler by wiping with rags, first across the grain, then lightly along the grain (see fig. 24). After the surface is filled and stained, brush on a thin coat of shellac. When the shellac has dried, steel-wool the surface lightly before proceeding with the finish.

4-17. *Applying the transparent finish.* Two types of transparent finishes are used for interior surfaces: the varnish finish and the sealer and wax finish.

4-18. Apply varnish with a clean brush, either flat or oval in shape. Take a full load of varnish on the brush but not enough to drip off. Brush the varnish out well, but brush no longer than is necessary. Several thin coats produce a better finish than one thick one. A thick coat may run, sag, or wrinkle and require excessive drying time. Allow at least 24 hours for drying between coats. After one coat has dried hard, rub the surface lightly with steel wool before applying the next coat. This removes all dust particles and nibs in the surface. The number of coats you apply will depend upon the absorptive nature of the wood and the desired fullness of the finish. If the priority of the appearance demands it, the final coat

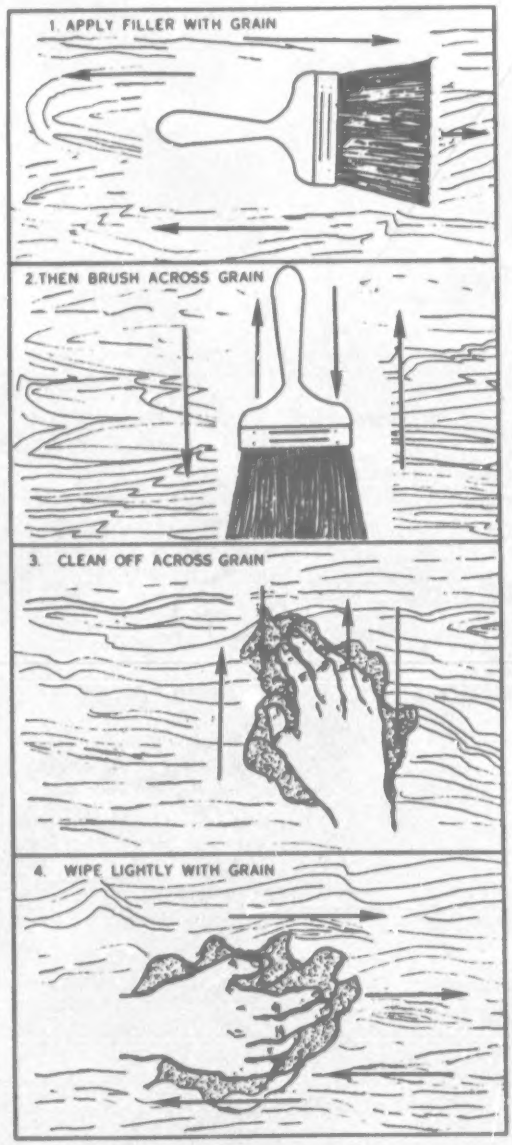

Figure 24. Applying filler to hardwoods.

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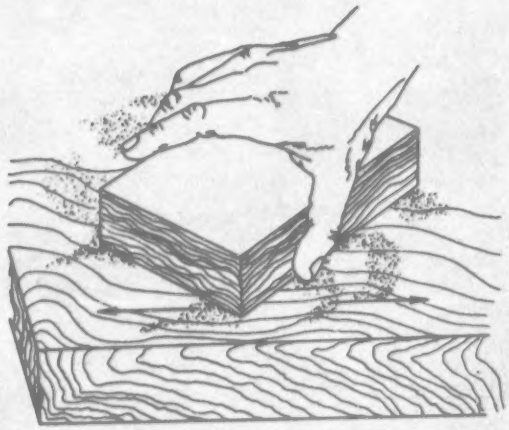

Figure 25. Rubbing surface with pumice stone.

may be rubbed with pumice stone (see fig. 25). When the finish is to be rubbed, the final coat should be varnish which meets Federal Specification TT–V–86b, Varnish, Rubbing, Cabinet. The varnish must be thoroughly dry and hard before rubbing. Use a felt pad to rub the surface with pumice and oil. A mineral oil, such as kerosene, should be used with the pumice powder to make a paste. Rub the surface with the pad, saturated with the pumice and oil, along the grain. Avoid rubbing through the finish at edges or curvatures in the surface. Wipe the surface clean occasionally to check for the desired luster. Finish the job by cleaning the surface with an oil furniture polish.

4-19. Most interior varnish surfaces will not warrant the additional work required for rubbing. A dull-luster finish may be obtained by using a flat varnish for the final coat. This varnish is self-leveling and drys with a satin finish.

4-20. *Refinishing transparent surfaces.* If the old surface is in good condition, and no change in color is desired, little preparation is necessary prior to refinishing. Light sandpapering and revarnishing, or light sandpapering and resealing are sufficient.

4-21. If the old surface contains deep scratches or areas worn through to bare wood, these defects must be repaired. On light-colored woods, apply a coat of hot linseed oil to the damaged areas; on dark-colored woods, apply oil stain. Seal the damaged area with shellac and carefully build up the thickness to that of the damaged area. The repaired area will appear darker than the old surface. This condition will correct itself in time, as the oil is absorbed into the wood. Avoid deep sanding of scratches in veneered surfaces as you may sand through the veneer coating. Deep sanding is permissible on wood planking.

4-22. For complete refinishing of old, stained wood, remove the existing finish with paint and varnish remover. Wash the bare surface to remove wax left by the remover. Sandpaper the surface lightly and refinish as new wood.

4-23. If a lighter stain is desired when refinishing, or if the existing color is dark and uneven, sand the area thoroughly. The color can be lightened when it is possible to uncover some bare wood. It may be necessary to use a bleaching solution by mixing 8 ounces of oxalic acid into 2 quarts of hot water. More than one application is often necessary. After the surface has dried, remove any raised grain with sandpaper and refinish as new wood.

4-24. **Coating Interior Floors.** Interior floors are not subjected to weathering as are exterior floors. Their appearance is expected to be better and the finishes more varied. Either opaque paints or transparent coatings are used on interior floors. Interior floors require much more surface preparation before refinishing than do exterior wood floors. They must be sanded smooth, filled, and sealed, before the finish coat is applied.

4-25. Pine floors may be finished with transparent coatings; however, these floors are usually painted. Pine is a softwood which dents and mars easily. Hardwood floors of oak, maple, or birch are generally always finished with transparent coatings.

4-26. Before applying any type finish to a new floor, remove all surface imperfections by sanding. Special sanding machines are used for sanding floors. A special edger is used for sanding along walls. You should seek advice from an experienced operator before attempting to use the floor sander. An inexperienced workman can cause heavy damage to a floor if the machine is not operated correctly. The machine must be kept in movement at all times. If the movement is stopped, the abrasive will cut deep grooves or depressions into the floor. These may be impossible to remove. You should sand the floor in a direction parallel with the boards. Cross sanding causes deep scratches across the grain of the boards. These scratches will require additional deep sanding (with the grain) to remove. When you complete the sanding operation, be sure you clean the area of all dust. Even though the sanding machine has a dust bag, the area should be cleaned with a vacuum cleaner.

4-27. If the floor is to be painted, a good grade of floor paint should be used. Prepare the primer by adding 1 quart of spar varnish and ½ pint of mineral thinner to 1 gallon of the floor

paint. Apply the priming coat with a brush, working it well into all cracks and end joints, and allow the priming coat to dry for 24 hours before filling open joints and cracks with a hard-setting putty. Apply the finish coat of floor paint without reduction. Brush the paint along the grain and work it well into the wood.

4-28. *Repainting wood floors.* Floors which need recoating will have the paint worn away in traffic lanes. The remainder of the surface may be in good condition. Spot-prime the worn areas and apply one finish coat of paint over the entire floor. If there is severe paint failure, such as flaking or alligatoring or excessive thickness buildup, strip the old coating from the floor, using paint and varnish remover. Be very careful while scraping not to damage the wood surface. This may prevent a need for resanding the floor. Clean the surface to remove any wax from the paint remover, and then repaint as you would a newly sanded floor.

4-29. *Applying transparent floor finishes.* Floors that are to be natural finished must be sanded with greater perfection than those which are to be painted. You should fill all open joints and cracks with a wood-base putty approximately the color of the bare floor. This putty can be made by mixing sanding dust from the floor with a casine or banana oil-base glue. When the putty has hardened, the repaired areas must be spot-sanded. Use a sanding block or vibrating sander for this operation.

4-30. Hardwoods with large pores must be filled to produce a righ, mirror finish. The filling operation is a hard and physically tiring job which should be avoided unless absolute perfection is desired. A paste wood filler is used on floors. You should thin the filler with turpentine or mineral spirits to a consistency of thick cream. Use a brush to apply it freely across the grain and work it into the pores. Work on small sections at a time. Allow the filler to set until the surface begins to lose its gloss and appears dull. Wipe off the filler with burlap sacking or use a floor buffing machine. The wiping operation is important, and is first done across the grain then lightly with the grain. The buffing machine is suitable for this operation as the pad rotates in a circular motion. You should allow the filler to dry for 18 hours before proceeding.

4-31. Various transparent finishes may be applied after the floor is sanded and filled. Floor sealer provides a more durable surface than shellac or varnish finishes. Shellac is used only on low-priority jobs or whenever the floor is required for immediate use. Varnish finishes are used for average traffic areas when a rich, luxurious surface is desired. The life and appearance of any of the surfaces can be extended by periodic waxing.

4-32. When shellac is used, apply it with a brush. Flow the shellac on with short strokes and do not overbrush. When two coats are used, steel-wool the surface between coats. This can be done with a power buffer equipped with steel wool pads. Since shellac dries hurriedly, the floor can be waxed and placed into service in a minimum of time.

4-33. The application of floor sealer requires no special skill. At one time it was believed that floor sealers had to be brushed on to achieve top results. Modern, labor-saving practices have proven these coatings can be applied effectively with a lamb's wool applicator or mop. Apply as much sealer as the floor will absorb. Spread additional sealer over areas that will absorb it. Wipe off all excess sealer from the floor before it becomes tacky. Before the first coat dries, burnish it lightly with steel wool and allow the sealer to dry overnight. Apply a second coat of sealer in the same way. Repeat the burnishing operation with a power buffer using steel wool pads. Again allow the sealer to dry overnight and complete the job by applying a coat of paste wax.

4-34. Varnish should be applied to the floor with a brush. You should apply a thin coat for the first coat. Allow the surface to dry overnight and remove the glaze by sanding or rubbing with steel wool. Wipe the surface with a dry cloth to remove the dust. Apply the second coat and follow the same procedure. Complete the job by applying a coat of paste wax to the surface.

4-35. *Refinishing transparent surface floors.* Deep sanding during the refinishing of transparent floors should be avoided whenever possible. Continuous sanding, especially in traffic lanes, can eventually remove enough wood to expose nailheads and tongue and groove joints. This would require replacement of the flooring. Deep sanding may also produce low places or hollows in the floor surface. Scrub the floor with soap and water to remove all grease or floor wax buildup. Use clean water to rinse and then dry the surface by dry-mopping. When the floor is thoroughly dry, steel-wool the surface, using a power buffer. Refinish the surface with one or two coats as required.

4-36. *Operation of power buffers.* We have discussed the use of power buffers in the finishing, refinishing, and maintenance of floors. Let's learn how to operate this machine properly. The unit is simply an electric motor with a handle and attachments ranging from soft pads to bristle or wire brushes. To change the attachment, unplug the cord, lay the machine on its side, and

Figure 26. Applying water stain.

rotate the attachment opposite the normal operating direction. This unclips the attachment for removal. Install the brush or pad you want to use and raise the machine to its operational position. When the machine is turned "on," the clips will lock and hold the attachment in place. During operation, do not try to manhandle the machine. By experimenting, you will find that lifting the handle will cause the machine to move to the left, lowering the handle to move to the right, and a neutral position will hold it in one spot. For operational safety, make sure the electrical connections are good and the electric cord does not get caught in the machine.

4-37. **Finishing Interior Wood Furniture.** When finishing furniture, make use of all the knowledge and skills you have learned in finishing interior woods. If the furniture is to be painted, use only interior paints or enamels. The surface must be well-prepared and undercoated. The application of transparent finishes on fine hardwood furniture will require the ultimate in surface preparation.

4-38. Water stain may be used instead of oil stain. Water stain does not fade or lighten as most oil stains do. Before applying water stain, dampen the surface with a wet cloth (see fig. 26). This will raise the nap in the grain of the wood. When the surface dries, remove the nap by hand-sanding with very fine grit sandpaper. Continue by repeating this operation until the nap no longer raises on the wood. The water stain can then be applied by brush. Applying the stain hot will cause it to have better penetration of the wood.

4-39. Hardwoods with large pores must be filled. You should use a liquid filler on furniture woods. Brush the filler across the grain to fill the pores. Allow the filler to stand until the surface looses its gloss. The first wiping strokes should be at right angles to the grain and should include a patting, or pounding action. This will pack the filler into the wood pores. It is very important from the standpoint of appearance that the excess filler be removed from the surface. You should apply the filler before an oil stain is used; but, you must always apply water stain prior to filling. Water stains will not penetrate the filler.

4-40. A good rubbing varnish that meets Federal Specification TT-V-86b should be used for finishing fine furniture. You should apply varnish with a brush in three thin coats. Allow each coat to dry at least 24 hours and steel-wool the surface by hand prior to applying the next coat. After the final coat is thoroughly dry and hard, it should be rubbed with rottenstone and oil. Rottenstone is a very finely powdered abrasive, similar to pumice stone. It is used in the same manner as pumice except that a soft cloth is folded

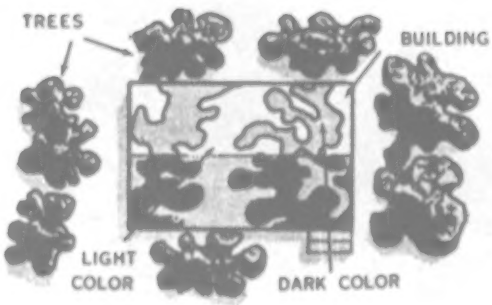

Figure 27. Pattern painting.

into a pad for rubbing. Final cleaning should be done with a clean, soft cloth moistened in benzene. For a brilliant, deep-luster finish, apply a paste furniture wax.

5. Camouflage Painting

5-1. Camouflage painting is a method used to hide or conceal the location of buildings or equipment from enemy observation. It is generally used in forward or combat areas to reduce the silhouette or shadow of a structure. This lessens the probability of the area's being a target for enemy ground fire or aerial bombing.

5-2. There are very few instances where straight lines or right angles appear in the general makeup of nature. When a building is placed in these natural surroundings, it will "stick out like a sore thumb," because the building is made up of straight edges and corners. The two types of camouflage painting used on exterior surfaces are identified as pattern and tone-down painting.

5-3. **Pattern Painting.** When pattern-painting a building, use two or three contrasting colors. The paint is applied in irregular patterns and shapes, as illustrated in figure 27. There is no definite rule governing pattern sizes, since they depend on the size of the structure, the type of surroundings, and the range of enemy observation. The patterns should be as large as practicable, since small patterns blend into one color and do not give reliable concealment. The colors should be chosen to blend with the background for the camouflage to be effective.

5-4. **Tone-Down Painting.** Tone-down painting blends colors to reduce contrast. Under ideal conditions, tone-down painting will cause a structure to almost disappear from view. From the air, the light-colored roof of a building standing against a light background is easily located by the shadow the building casts. Against a darker background, the light-colored roof is detected by its own contrast with the background. The ideal is to have a dark-colored roof on a dark background. This will cause the building and its shadow to disappear from view.

5-5. You may apply camouflage paint with a brush, spray gun, roller, or any convenient method at hand. To obtain the best results, follow the manufacturer's instructions. Failures are caused by improper mixing, application during bad weather, and use of the wrong type of paint for a surface. Normally, the requirements for camouflage paints are dull finish, no fade, easy to apply, and cover in one coat. You may apply camouflage paints to steel or masonry structures as well as wood. The methods of painting masonry will be discussed in Chapter 2, and metal in Chapter 3.

5-6. Camouflage paints may be procured in various colors, such as light or dark green, field drab, sand, earth brown, earth red, earth yellow, and olive drab. These colors, together with black and white, will provide sufficient variety for most camouflage painting. The following basic color schemes are recommended as effective for painting patterns on buildings in various regions:

a. In the temperate zone or jungle—olive drab, field drab, or another light color to match the terrain, and black.

b. For desert terrain—sand, earth yellow, earth red, or another light color to match the terrain, and black.

c. On snow terrain—white and olive drab or black and white are very effective.

5-7. In combat zones, the choice of camouflage paint is determined by the surrounding area. Normally, issue paints from supply are available. If not, you will have to use your own ingenuity to make them. Crankcase oil drainings, asphalt, clay and colored mud may be applied to change the color of surfaces.

CHAPTER 2

Painting Masonry Surfaces

MASONRY SURFACES, such as brick, concrete, stucco, stone, and cinder or concrete blocks are painted for two reasons: for waterproofing and to improve their appearance.

2. As you remember from Chapter 1, we discussed the procedures for preparing and coating wooden surfaces. Many of the same methods are used to apply paint to concrete and masonry surfaces. However, different materials and some additional tools are used to clean the surfaces of such buildings. These buildings will require special treating before the protective coating is applied.

3. As a protective coating specialist, you must be able to recognize conditions on masonry surfaces which will affect the life or appearance of protective coatings. You must know how to properly prepare and treat these surfaces prior to application of the protective coating.

6. Characteristics of Concrete and Masonry Surfaces

6-1. The painting of concrete and other masonry surfaces is complicated by several factors. New surfaces will generally require more preparation than old surfaces to obtain a durable and lasting paint job.

6-2. New concrete structures and the mortar joints of masonry structures contain a large amount of moisture. This moisture was introduced at the time the cement and aggregates were mixed during construction. Concrete does not dry out as regular dirt and water mud does. It hardens from a chemical action by hydration. Although the free water disappears as the concrete sets or hardens, the concrete will remain damp and retain moisture for some time. This high-moisture content adds to the difficulty of painting the surfaces.

6-3. New concrete and mortar will also contain considerable amounts of alkaline substances. The alkali will be located all through the concrete and it is soluble in water. Alkaline substances which are on or near the surface will gradually be neutralized and washed away by rainwater. Those which lie more deeply in the masonry or concrete will be carried to the surface over a very extended period of time. This is caused by a leaching action of the moisture in the concrete. These deposits, as they reach the surface, cause rapid deterioration of the protective coating.

6-4. New concrete surfaces are likely to be soiled with oil from forms. The surface may be glazed as the result of having been cast against smooth, nonabsorbent forms, such as metal. Either of these conditions will affect the satisfactory performance of paint coatings.

6-5. Old, unpainted masonry and concrete surfaces may become badly soiled with dirt. Moisture and alkali deposits may have disappeared on old surfaces but there may be hard, crystal-like spots of efflorescence. These surfaces must be thoroughly cleaned before applying a protective coating. Old masonry surfaces of building blocks, brick, or stone may have heavy mortar stains. These are the result of poor cleaning at the time of construction. Masonry walls may have cracks in the mortar joints. These are caused by foundation settling. All of these defects must be repaired before the application of a protective coating.

6-6. You have learned the common characteristics of concrete and masonry surfaces which affect the application and durability of protective coatings. Now, let's learn the methods of treating, repairing, and preparing these surfaces prior to painting or repainting.

7. Preparation of Exterior Surfaces

7-1. Many paints have been developed by manufacturers who claim them to be unaffected by conditions of the concrete surface. The fact remains that there is no substitute for adequate surface preparation.

7-2. **Removing Glaze.** Some concrete surfaces are so dense or glazed that they will not retain paint well. The ideal situation would be to allow

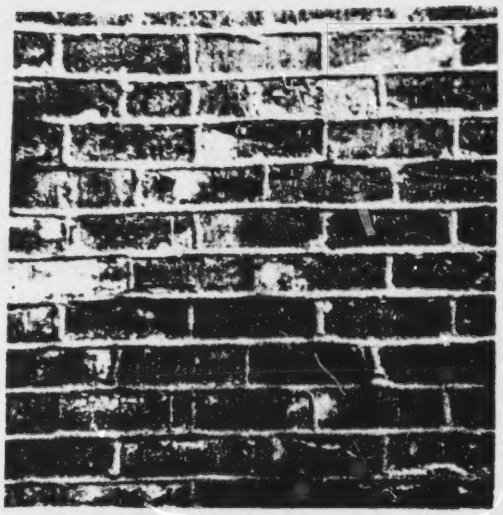

Figure 28. Efflorescence on brick.

these surfaces to expose to the weather for a 6- to 12-month period. If this is impractical, use other means to reduce the surface smoothness. You can usually remove the glaze on relatively new concrete surfaces with steel brushes, abrasive stones, or by light sandblasting. Keep in mind that you only want to remove the glaze from the surface. Excessive roughening or pitting is unnecessary and undesirable. Old surfaces may require more extensive sandblasting. Complete information on the use of sandblasting equipment will be covered in Chapter 3. If all mechanical means fail, you may roughen or etch the surface with an acid solution. You can use a 10-percent muriatic acid solution and apply it to the surface with a bristle brush. Allow the solution to remain on the surface for 5 to 10 minutes and then hose it off with water.

CAUTION: You must always wear goggles and rubber gloves when using this acid. When mixing the acid solution, always add acid to water to prevent splattering. Never pour water into the acid.

7-3. **Testing for Alkali.** You will find it impossible to detect alkali deposits by sight alone. These conditions are generally associated with moisture movement in the concrete. To detect the presence of free alkali, dampen the surface with water. Apply a few drops of a 1-percent solution of phenolphthalein in alcohol to several spots over the surface. If alkali is present, the drops of solution will turn a pink, red, or purple color, depending on the concentration of alkali.

7-4. **Neutralizing Alkali.** There are several methods you may use to treat alkali surfaces prior to applying the protective coating. The treatment used depends on the age of the surface and the concentration of the deposit. You can treat new surfaces, when they are approximately 3 weeks old, with a phosphoric acid-zinc chloride solution. You make the solution by adding 3-percent phosphoric acid and 2-percent zinc chloride to water. Apply the solution to the surface with a stiff-fiber brush. Allow the surface to dry for at least 24 hours. The solution forms a coating of insoluble compounds on the surface during the neutralizing action. Apply the protective coating to the surface without further cleaning, which could remove the compounds. You can treat surfaces which have aged more than 3 months with zinc-sulphate solution. Prepare the solution by adding 2 pounds of zinc sulphate to 1 gallon of water. Apply the solution with a stiff-fiber brush. After drying, you should remove all loose particles with a dry scrub brush. The surface deposits formed by this solution are water soluble and should be removed by dry-brushing, prior to application of the protective coating. Older concrete surfaces, which have aged for a considerable length of time and show minute traces of alkalinity, can be neutralized with an acid treatment. Apply a 10-percent solution of muriatic acid and water. Rinse the surface with water to remove the acid and allow the surface to dry thoroughly before applying the paint.

7-5. **Removing Efflorescence.** The white crystalline deposit which forms on masonry walls, especially those made of brick, is known as efflorescence. Figure 28 shows severe efflorescence on a brick wall. You may remove light deposits with a steel wire or fiber brush. If this fails, you must use an acid solution. Wet the surface with water and apply a 20- to 30-percent solution of muriatic acid. Allow the solution to remain on the surface for 5 minutes. Scour the area with a stiff-bristle brush, working on small areas of about 2 feet square. After this treatment, wash and flood the surface thoroughly with clean water. CAUTION: A 20- to 30-percent solution of muriatic acid is considered to be a strong solution. Always wear rubber gloves, goggles, and acid protective clothing when using this aid.

7-6. **Repairing Joint Cracks.** Masonry walls built of brick, concrete blocks, or cinder blocks may develop cracks in mortar joints. These cracks result from foundation settling or other conditions which allow wall movement. These cracks usually appear at corners or below windows. Such cracks must be repaired, not only for appearance but to waterproof the surface. Even though great care is taken to match the color and texture of the old mortar joints, these repairs will always be visible. For this reason, masonry buildings

Figure 29. Removing old mortar.

which have numerous joint repairs are often painted to enhance the overall appearance of the structure. Where large, deep cracks appear in the mortar joint, you must remove the mortar from the joint. You can do this by using a hammer and a small cold chisel, as shown in figure 29. Chip out the mortar, the full width of the joint, to a depth of 2 inches when a leak must be stopped or to ½ inch for routine repair. Remove all dust and loose material with water from a hose after the cutting has been completed. You should then prepare some mortar by mixing 2 parts of fine masonry sand and 1 part of masonry cement. Prehydration of mortar will greatly reduce shrinkage. To prehydrate the mortar, mix the dry ingredients with just enough water to produce a damp mass of such consistency that it will retain its form when compressed into a ball with the hands. Allow the mortar to stand at least 1 hour and not more than 2 hours. After this has been done, mix in a required amount of water to produce a stiff but workable consistency. Filling the joint is called repointing. This is done with a pointing trowel, as illustrated in figure 30. You should pack the mortar tightly into the joint in thin layers, about ¼-inch thick. Push the mortar into the joint with a forward motion in one direction from a starting point. This will reduce the possibility of forming air pockets. After the joints are filled, you should tool them, as shown in figure 31, to match the old mortar joints.

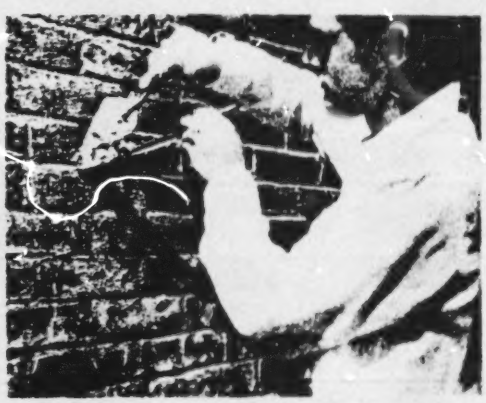

Figure 30. Repointing a joint.

7-7. Repaired mortar joints will recrack and reopen if the condition which caused the original crack still exists. If you suspect the building is still settling or moving, repair the mortar joints, using the following procedure. Remove the mortar from the joint to a depth of about 2 inches. Pack the opening with cement mortar to within ½ inch of the surface. Finish filling the joint with number 1 caulking compound. This compound will dry with a tough exterior skin and resist breaking. The underbody will remain soft and pliable. The elasticity of the compound will prevent the crack from reappearing as the building continues to settle.

Figure 31. Tooling a joint.

7-8. **Repairing Surface Defects.** Before painting concrete surfaces, you should repair all pits, chips, holes and honeycomb areas. These surface defects can be filled with grout. Grout is made by mixing one part masonry cement to one part fine masonry sand. Masonry cement must be used because the lime in masonry cement works as a binder to cause the grout to adhere to shallow defects. Only enough water should be used to make the grout into a heavy paste. You should wet the surface and allow all free water to drain off before applying the grout. Use a stiff brush to scrub the grout into all irregularities of the

Figure 32. Sealing cinderblocks.

surface. As the grout begins to set, smooth all areas and level them with the surface, using a cement trowel. Grouted areas should be cured by spraying water on them several times a day for 2 or 3 days or by covering them with wet burlap pads.

7-9. **Sealing Building Blocks.** Concrete and cinder building blocks are highly porous. The blocks are made from a dry, stiff concrete mixture which does not consolidate completely during the manufacturing process. The blocks have poor ability to resist penetration by wind-driven rain or water from other sources. Any attempt toward sealing these blocks should be on the surface facing the water source rather than the dry side. You may use cement-water-sand paint to seal these surfaces. Mix the paint using 1 part masonry cement, 1 part of fine masonry sand, and enough water to make a thick consistency paint. You apply the paint and scrub it into the surface with a stiff-bristle brush, as shown in figure 32. Apply the paint heavily enough to fill the many small voids in the block surface. To seal cinder blocks, you should flood the surface with water prior to applying the cement paint. After painting, cure the paint for 72 hours by wetting the surface at least three times each day.

7-10. **Removing Oil and Grease.** Oil film and grease spots can be removed from masonry with steel brushes, abrasive stones, or preferably, by light sandblasting. You may use solvents to remove heavy grease deposits. After using solvents, the area should be scrubbed with hot water and detergent. A solution of ¼ pound household lye to 1 gallon of water can be used to remove small oil stains. After using the lye solution, you must flood the area with water to remove all traces of the lye. You should wear rubber gloves and goggles when using the lye solution. On deep oil stains, you should use trisodium phosphate. This chemical can be obtained in powder form and mixed with water to make a paste. Apply the paste over the stain and allow to stand for 30 to 45 minutes. Remove the dried paste by scraping, brushing, or sweeping; then, wash the area with detergent and water.

7-11. **Preparation of Previously Coated Surfaces.** Painted masonry with only normal deterioration of the paint may be repainted after cleaning. Surfaces which are damaged or show abnormal deterioration of paint will require additional preparation. You should repair any cracks, damaged mortar joints, or surface defects. If the deterioration of the old paint was caused by alkali deposits, glazing, or efflorescence, you should treat the surface to prevent recurrence.

7-12. *Removing paint from masonry.* You can remove paint from masonry surfaces by several methods. Acid-resistant paints, plastic paints, and epoxy paints are very difficult to remove. These paints can be removed by sandblasting. To remove oil-base paints from a smooth concrete surface, you can use either heat or solvent paint remover. Use the same procedures used to remove paint from wooden surfaces. The surface must be smooth enough to allow scraping of the old paint with a putty knife. Loose and scaling paint on rough concrete building blocks, or brick can usually be removed by using a lye-water solution. This solution will break down and dissolve old paint so it can be flushed from the rough surface with water. You may use solvent remover on sound oil base paint prior to washing with the lye-water solution and flushing. Cement water paint containing lime can be removed or reduced by using a 10- to 20-percent muriatic acid-water solution. You apply the solution with a stiff-bristle fiber brush. Allow it to set for 10 minutes and flush the surface with water. CAUTION: Always wear proper protective clothing and goggles when working with remover solvents, acid solutions, or lye water. Keep in mind that it may not be necessary to remove all paint from surfaces to be repainted. Remove only enough paint to provide a sound and solid base for the new protective coating. If the surface must be completely cleaned, sandblast the surface and you will find that this method produces better results than other types of paint removal.

7-13. Once the conditions, which make concrete and masonry difficult to paint, have been remedied several paint materials can be used satisfactorily on these surfaces.

8. Application of Exterior Coatings

8-1. Several types of paint used on exterior walls include cement-base paint, oil-base paint, latex paint, and rubber-base paint. They all have a damp-proofing effect, but the oil base is usually more effective in this respect. Latex and cement-base paint produce coatings which permit the structure to "breathe"; that is, moisture vapor transmitted from the inside to the outside of the structure will pass through the paint film. Blistering caused by severe moisture conditions is thereby reduced or eliminated.

8-2. **Applying Cement-Base Paint.** Cement-base paint can be obtained commercially in two types: class A and class B. You should use class A, which contains more lime, for fine textured surfaces. Use class B, which contains siliceous materials, for open-textured surfaces. The paint comes in powder form, in white or colors. Mix the cement powder with sufficient water to give a thick, creamy consistency and allow it to stand for 15 to 30 minutes. Remix prior to use and stir frequently during application. Dampen surfaces prior to paint application with fine water spray, and allow water to penetrate a few minutes. You then apply the paint with a stiff-bristle brush and scrub it thoroughly into surface voids. Cure the first coat for 24 hours, using a fine water spray. Start the curing as soon as the paint is hardened sufficiently to resist damage. Allow free film of curing water to disappear before you apply the second coat of paint. After the second coat has set, dampcure it by spraying two or three times a day with water for the next 2 days.

8-3. **Applying Oil-Base Paint.** When using oil-base paint on concrete and masonry surfaces, be sure the surfaces are dry. Avoid painting in damp weather, early in the morning, or late in the afternoon because concrete surfaces chill and collect moisture during the night. Be sure you have properly prepared unpainted surfaces. Remove foreign matter and loose particles, and roughen glazed surfaces. New close-textured concrete surfaces should be pretreated to inhibit alkaline reaction with oil-base paint. Brush on a solution of zinc sulphate dissolved in water at a concentration of 2 to 3 pounds per gallon. When the solution dries, dust the surface lightly to remove any loose salts. Be careful not to remove the crust formed on the surface or the advantage of pretreatment will be lost.

8-4. Masonry surfaces of concrete or cinder building blocks should be sealed, as was explained in paragraph 7-9, prior to applying oil-base paint. Filling surface voids with oil- or varnish-base paint would require abnormally large amounts of paint. These paints are not adaptable to the scrubbing action necessary to work the paint into the surface voids.

8-5. You can apply oil-base paints with a brush, roller, or spray equipment. The first, or priming coat, should be brushed on. The paint for this coat should be reduced with spar varnish in the proportion of 1 quart to 1 gallon of base paint. Apply the paint with an old, worn brush. The rough abrasive surfaces of concrete wear new brushes in a hurry, so use your old brushes on these surfaces. Allow the paint to dry at least 24 hours and then apply a second coat. Use the reduced paint for the second coat and allow it to dry for at least 24 hours. You then apply the third coat, using the paint as it comes from the can without thinning. The second and third coats may be applied with a roller or spray gun.

8-6. Previously painted surfaces, on which the old coating is sound or has normal deterioration, can usually be repainted with one coat of oil-base paint. When necessary, you should treat and spot-prime areas of the surface prior to painting.

8-7. **Applying Latex Paints.** Latex paint is manufactured by emulsifying various chemical formulas in water rather than disolving them in mineral spirits. These emulsions look like the milky latex of the rubber tree and are sometimes mistakenly referred to as rubber-base paint. Water-thinned latex paint, particularly that made with polyvinyl acetate emulsions, is very suitable for use on exterior concrete and masonry surfaces. This paint is moisture and alkali-resistant and it has desirable deterioration characteristics. It resists blistering, cracking, and flacking, and normally deteriorates through the chalking process.

8-8. You can apply exterior, latex paint by brushing or with a roller coater. Because of the excellent alkali resistance and permeability to moisture vapor, latex paint requires little or no surface preparation but cleaning. It requires a shorter aging period for concrete and masonry surfaces than does oil-base paint; although, a period of not less than 3 to 4 weeks is recommended.

8-9. Exterior latex paint is adaptable to painting open-textured building blocks without a preliminary filling or grouting treatment. You can work the paint into the surface voids with a whitewash brush by using a light scrubbing action. Although latex paint dries to the touch in 30 to 40 minutes, it should not be applied in temperatures below 40° F. A 1- to 12-hour drying period should be allowed between coats. The paint requires no water curing. You can apply the second coat to building blocks with a regular paint brush.

8-10. Many of the substances used in the manufacture of latex paint are also used to make plastics. For this reason, latex paint is sometimes called plastic paint. Any of the synthetic-resin paints might be called plastic paint because the phenolic, vinyl, and other synthetic resins commonly used in it are varieties of plastic.

8-11. **Applying Vinyl Paint.** Exterior vinyl paint contains materials that are related to plastic coatings used in upholstery and floor coverings. This paint can be thinned as necessary with water. It has many of the characteristics of latex paint and you can apply it to exterior concrete or masonry with a brush or roller. The paint dries fast, in 10 to 30 minutes, and can withstand water after that time. It cures completely in 12 hours by forming a tough, long-lasting film. It has a disadvantage; it should not be applied during cold weather. Do not apply exterior vinyl paint when the temperature is below 50° F. or when the temperature will fall below 50° F. during the 12-hour curing period.

8-12. **Applying Acrylic Paint.** Acrylic paint is also composed of a form of plastic in water. You can apply acrylic paint with a brush or roller coater. This paint retains its color longer and dries faster than other so-called plastic paint. You can apply it in all kinds of weather—hot, humid, or cold—as long as the temperature is slightly above freezing. This paint dries to the touch in 10 to 20 minutes and you can apply a second coat after 1 hour. During application, you should flow the paint over the entire surface with only a minimum of brushing or rolling.

8-13. **Applying Chlorinated-Rubber Paint.** True rubber-base paint consists of synthetic or natural rubber dissolved in a liquid such as toluene or solvent naphtha. Masonry surfaces to be coated with this paint should be dry and clean. You should apply a minimum of three coats on new or unpainted masonry surfaces. Under severe conditions and for maximum durability, four coats should be applied. For best results, you should apply the paint directly to the concrete or masonry surface. No primer is needed. You can apply the paint either by brush or roller coater. If the paint is to be applied over an old coat of paint, you should paint only a small test section to determine whether the solvents used in the chlorinated rubber paint will soften or remove the old coating. If the old coating is affected, it should be completely removed before the surface is repainted. You should thin the first coat of rubber-base paint with approximately 1 quart of xylene or toluene per gallon of paint. You should thin intermediate coats with 1 pint of xylene or toluene per gallon of paint. Apply the finish coat undiluted just as it comes from the container.

8-14. **Painting Cement-Asbestos Surfaces.** Cement-asbestos is manufactured from Portland cement and asbestos fiber. It is used for exterior siding application in the form of shingles or boards. It is very hard and brittle, and is highly fireproof. The natural color of the board is grey, but the shingles are available in white or colors. The shingles are nailed in rows over a wood subwall so each row partially overlaps the row immediately below it. This overlap prevents the shingles from lying flat and results in frequent breaking of the shingles. Sometimes, during routine maintenance, the broken shingles are replaced with new shingles of a different color. This results in a spotted and unattractive appearance to the building. These buildings may be painted to improve their appearance.

8-15. Before painting cement-asbestos surfaces you should clean them and remove any stains with solvent or by washing. All loose shingles should be renailed. Do not strike the nail with a sharp blow of the hammer, or you may crack the shingle. If additional nails are required, do not attempt to drive the nail through the siding; use an electric drill motor with a ⅛-inch twist bit and very carefully drill holes through the shingles as required for new nails.

8-16. A two-coat coverage is recommended for cement-asbestos shingle surfaces of mixed colors. You should apply the paint with a brush for best results. Apply a coat of exterior paint primer, or wood undercoat, as the first coat. After the priming coat dries, apply a finish coat, using titanium-lead-zinc exterior house paint. The priming coat should be tinted the approximate color of the finish coat. Brush the paint well into the pores of the cement-asbestos and cover all edges and cracks between the shingles. When painting cement-asbestos boards, finish the painting with long, parallel strokes of the brush.

8-17. You have learned some of the more common problems in the preparation of exterior masonry surfaces, and the application of protective coatings to these surfaces. Now, let's discuss the methods of preparing and coating interior masonry surfaces.

9. Preparation and Coating Interior Masonry Surfaces

9-1. Interior walls and ceilings are divided into two types of construction: wet-wall and dry-wall. Wet-wall construction refers to the application of a wet plaster directly to a masonry surface, or over metal lath or furring strips on frame construction. Dry-wall construction refers

to the use of wallboard, such as sheetrock, in place of plaster on interior surfaces.

9-2. **Preparation and Coating Wet-wall Surfaces.** To better understand the procedure used for repair and surface preparation of wet-wall surfaces, let's learn something about the types and usage of plaster. The many types of plaster, while similar in composition and method of application, are each used for different utilization requirements. They are explained as follows:

a. Gypsum Plaster. Gypsum plaster is the most widely used in ordinary construction since it can be applied directly to interior masonry. It is also applied to metal lath or furring over frame walls.

b. Lime Plaster. Lime plaster, the type found in many older buildings is generally used for the same type work as gypsum plaster.

c. Keene's Cement Plaster. Keene's cement plaster produces a very hard, moisture-resistant surface. It is used in areas subject to continued moisture conditions, such as latrines, bathrooms, and kitchens.

d. Portland Cement Plaster. Portland cement plaster is applied directly to interior masonry walls. Elsewhere, it should be applied over metal lath. It should never be applied over gypsum products. It is used in similar areas rather than Keene's cement plaster because of economic reasons.

9-3. During construction, plaster is applied in a series of coats known as scratch, brown, and finish. Applications and mixes vary to meet required uses. The three-coat method of application for gypsum plaster is explained as follows:

a. Scratch Coat. This coat consists of a mixture of sand and light aggregate, and gypsum plaster. The sand or aggregate content is increased when the scratch coat is applied directly to masonry. It must be applied to metal lath with sufficient pressure to form a good bond. The scratch coat is left with a rough surface so it will accept the next coat.

b. Brown Coat. This coat is also composed of sand or light aggregate and gypsum plaster. The sand or aggregate content is increased over that used for the scratch coat. It is applied after the scratch coat is hard. It is laid and straightened to form a true surface. It is left rough to receive the finish coat.

c. Finish Coat. A typical white finish coat may be composed of lime putty and calcined gypsum. It is applied over a partially dry, brown coat or over a dry coat which has been wetted. This coat is laid thinly and brought to a true, even surface. After being allowed to dry a few minutes, it is troweled to a smooth finish coat.

9-4. *Minor repair to interior plaster.* As a protective coating specialist, you should know how to make minor repairs to interior plaster prior to applying a protective coating. Large areas on which there is excessive damage, or which require the replacement of large areas of plaster should be left to the masonry specialist. Minor repair should be limited to patching cracks, holes, and repairing small spots of loose or damaged plaster on interior wall and ceiling surfaces. The equipment you will need for making minor repairs consists of a spatula or putty knife, a small diamond-shaped pointing trowel, a sharp chisel, a linoleum knife, a hammer, and a shallow mixing pan.

9-5. *Repair of structural cracks.* Structural cracks are easily identified. They are usually large and well defined, extending across the surface and entirely through the plaster. They generally develop during the first year after construction, and in most cases can be successfully and permanently repaired. To repair a structural crack, use a linoleum knife or chisel to cut out and remove loose material. Cut the crack to a "V" shape making the surface opening narrower than the bottom of the crack. Widen the crack just enough to insure a good bond between patching plaster and old plaster and lath. Brush out all loose material and thoroughly wet the edges of the groove and then press the first coat of patching plaster firmly into place, fitting the groove almost to the surface. Allow it to set until nearly dry but not hard, then complete the patch by applying a coat of finishing plaster. Strike all repair plaster off flush with the surface and trowel smooth. Give special attention to the edges of the patch to insure a firm, solid bond between old and new plaster.

9-6. The patching plaster may be job-mixed as follows:

a. The first coat should be composed of one part fibered gypsum plaster and two and one half parts of plastering sand, by volume, mixed with clean water to a uniform color and workable consistency.

b. Materials for the second coat may be either a gypsum plaster or a mix of one part hydrated lime and one-half part calcined gypsum mixed with water to a suitable consistency.

9-7. A small amount of casein glue added to the above mixes insures easier application because it tends to retard the setting time of the mix. The addition of glue also prevents shrinking of the mix and aids in forming a better bond with the old plaster.

9-8. In lieu of the job mixes described above, you may use a commercial patching plaster. This

material is known as *spackling compound*. It is a mixture of plaster of Paris and powdered glue mixed with clean water to the consistency of soft putty. The quantity of any patching material must not exceed that which can be applied within 30 minutes after mixing. Never retemper (add water to) plaster material that has begun to dry and harden. Retempered plaster will dry out soft and become crumbly.

9-9. *Repairing shrinkage cracks.* Shrinkage cracks are fine, hairline cracks which are much less noticeable than structural cracks. These cracks may form an alligator or spider-web pattern over small areas of a ceiling or wall surface and are usually the result of the surface drying too rapidly, insufficient troweling, or no troweling before the surface is too dry. Shrinkage cracks do not extend entirely through the plaster but are limited to the surface. You can fill these cracks with a white-lead putty. You can make the putty by mixing white lead and turpentine to a thin paste. Scrub the paste into the cracks and wipe off all excess with a cloth folded into a pad.

9-10. *Repairing map cracks.* Map cracks form a pattern in the surface similar to shrinkage cracks. They are more defined than shrinkage cracks but are not nearly so wide as structural cracks. Map cracks penetrate through the plaster and are generally caused by an improper bond between the plaster and lath. You can use spackling compound to fill these cracks. Work as much compound into the crack as possible and smooth the surface. Use a cloth to remove all excess compound before it dries.

9-11. *Repairing loose plaster.* Loose plaster is indicated by bulging and cracking of the plaster surface. The extent of loosened plaster can be determined by lightly tapping the surface with a small hammer. The resultant sounds will indicate the extent of the loose area. Loose plaster is usually the result of excessive moisture. In severe cases, the fasteners holding the lath to the structural frame will corrode and allow both the lath and plaster to bluge or sag. Prior to repairing the damaged plaster, you should locate and eliminate any source of moisture. To make the repair, you must remove all loose plaster. Begin at the center and work back into the surrounding area to a point where the plaster is solid. Replace defective laths and securely refasten all laths which have become loosened.

9-12. A patching plaster that is compatible to the old plaster should be used. To obtain best results, apply the patching plaster in at least two coats. Use the patching plasters explained in paragraph 9-6 to repair gypsum or lime plaster surfaces. Apply a scratch coat and then a finish coat.

9-13. To patch portland cement plaster, the edges of the surface surrounding the defective area should be thoroughly and continuously wetted for at least 1 hour. Just prior to applying the patch, dust the edge of the exposed plaster with a light coat of portland cement. Press the first coat of portland cement plaster into the repair and fill it nearly to the surface. Scratch or roughen the surface of the patch with a wire brush, or nail, to make a base for receiving the finish coat. Thoroughly cure the first coat by keeping it moist for at least 72 hours. Then allow it to dry thoroughly, not less than 7 days, prior to applying the finish coat.

9-14. The finish coat should be of the same composition as the first coat. Just prior to application of the finish coat, redampen the patch area with water. Press the plaster firmly into the remaining cavity with a trowel. Float the plaster to a smooth, even surface, then trowel to the same texture as the surrounding surface. Keep the patch moist for at least 3 days.

9-15. Portland cement patching plaster should be mixed on the job shortly before it is to be used. It is composed of one part portland cement, three parts plastering sand, and one-fourth part lime putty.

9-16. Keene's cement plaster surfaces can be repaired by using the methods stated in the preceding paragraphs, with one exception: Keene's cement plaster must be used. Since this plaster is obtained commercially, the manufacturer's specific instructions for mixing and application should be followed.

9-17. *Painting plaster surfaces.* New plaster should be aged for a period of 60 days prior to painting with oil-base paint. This is necessary to allow for moisture removal. In the case of lime plaster, the surface alkalinity will be greatly reduced. Under excellent drying conditions, the aging period may be safely cut to a minimum of 30 days. When latex or other water paint is to be used, a drying-out period of 2 weeks, or as long as is practicable, is recommended.

9-18. Once the surface has aged sufficiently, you can apply the protective coating. It is to be noted that considerable similarity exists between painting interior plaster and interior woodwork. The same types of interior paint are used, and the methods of application are the same. Flat, semigloss, or gloss, interior, oil paint can be applied to new plaster, over a primer-sealer. You should use a pigmented, oil, primer-sealer recommended for masonry, and it should be applied by brush. The primer coat should be followed by a coat of enamel undercoater. The undercoater and sealer coats should be tinted to ap-

proximately the same color as the final coat. If a two-coat paint system is satisfactory from an appearance standpoint, the enamel undercoater may be omitted as an economy measure. The undercoater and the finish coat may be applied with either a brush, a roller coater, or a sprayer.

9-19. A two-coat system, using interior latex or other water-thinned, plastic paint, may be applied to new plaster. No special primer is needed unless the plaster is extremely porous. You can apply these water paints with a roller coater. You should work the paint well into the surface, by using crisscross strokes, until all holidays disappear. Finish the area by using long, parallel strokes.

9-20. Calcimine paint can be applied to new plaster that has aged for the minimum time. Before applying the paint, you should apply either a glue or varnish size coat. The watered glue, or varnish-thinned with 1 quart of turpentine per gallon, should be applied by brush. After the size coat dries, use a special calcimine brush to spread the paint in one thick coat. Spread it out evenly with the least amount of brushing. If the edges dry out before an area is covered, dampen them with clear water, using a clean brush. This will help eliminate lap marks. After painting, you should open all windows and doors. If it is winter, heat the room to eliminate excessive moisture in the air. Slow drying often causes a spotted appearance.

9-21. Chlorinated, rubber-base paint, for interior use, can be applied to new plaster in areas subject to heavy soiling. Rubber-base paint has reasonably good washability. The surface must be dry and should be aged for a minimum of 30 days. No primer is needed. You should brush on the first coat, which is thinned with 1 quart of xylol to 1 gallon of paint. The remaining coats can be applied with a roller coater.

Figure 33. Taping a wall joint.

9-22. *Repainting old plaster surfaces.* Old plaster surfaces should be sound, for repainting. You should repair all damaged areas. Surfaces to be repainted with the same type paint as the original paint require no preparation other than cleaning. You must always remove old calcimine paint before repainting these surfaces. The calcimine paint can be washed off with warm water and detergent. Do not attempt to remove the size coat. When you use chlorinated rubber-base paint for repainting, always make a test patch to insure that the rubber-base paint is compatible with the old paint. Whenever possible, you should accomplish all repainting with a one-coat coverage.

9-23. **Preparation and Coating of Dry-Wall Surfaces.** Generally speaking, dry-wall construction refers to the use of a gypsum plaster board commonly called sheetrock. This wallboard is composed of a gypsum core, encased in a heavy manila sheet on the face side, and a strong paper cardboard liner on the back. It is available in ¼-, ⅜-, or ½-inch thickness. Sheets cut to a 4 x 8 foot size are considered standard for ceiling and wall construction; however, it is manufactured in other sizes. The ends of the sheets are cut square to make butt joints, while the face side edges are recessed 1½ inches to allow for tape and bedding of cement covered joints. The ½-inch board is used, in general, for ceilings and interior partitions. In some instances, two thicknesses of ⅜-inch board are laminated together on the job to form a strong, highly fire-resistant, wall material.

9-24. On new construction, it is the carpenter's job to nail, or otherwise secure, the sheetrock to the ceiling and wall areas. As a protective coating specialist, it will be your job to further prepare and apply the protective coating to these surfaces.

9-25. To prepare new sheetrock surfaces for painting, you must tape and bed all joints and corners; cover all nailheads, and, in most cases, apply a stipple coating to the surface.

9-26. *Taping and bedding joints.* Perforated tape must be applied over the joints where two pieces of sheetrock meet. Obtain a clean container and mix the joint cement to the manufacturer's instructions. Use a wide-blade putty knife to apply the cement into the recess along the joint. Tear a piece of perforated tape from the roll long enough to cover the entire joint. For

Figure 34. Taping an inside corner.

extremely long runs, the tape may be worked in 6- to 8-foot lengths. You then use a putty knife to imbed the tape into the cement. Start at one end and align the tape to fall over the joint. Place the knife across and near the end of the tape. Hold that end of the tape in place with one hand and pull the knife along the tape with the other hand. Apply enough pressure on the knife to imbed the tape into the compound. Be sure you remove all wrinkles and air bubbles from under the tape. Figure 33 illustrates the application of the tape to a wall joint. After the tape is in place, cover it with a thin coating of compound.

9-27. You can tape inside or outside corners in much the same manner as flat joints. Apply the joint cement compound along the edges of the sheetrock where they meet to form the corner. Tear off a piece of tape and fold and crease it along the center so it will fit into or around the corner. Use the putty knife to imbed the tape into the compound so it forms a square and straight line corner, as illustrated in figure 34.

9-28. After the taping coat has dried, you should apply a second and third coat of compound over all joints. The joint cement will shrink as it dries, and three-coat coverage will insure a proper buildup of compound to conceal the joint. You can use a putty knife to apply the cement to the joint and then use a cement trowel to level and smooth the compound. This operation is illustrated in figure 35. Each coat should be applied to a slightly wider area than the preceding coat. Feather the edges and smooth the joint by using the trowel. When the final coat is dry, sandpaper the joint smooth to blend with the balance of the surface.

9-29. *Covering nailheads.* All nailheads must be recessed and covered with joint cement. Do not leave any portion of the nailhead where it will be contacted by the protective coating. Nailheads will eventually rust and stain the protective coating unless they are completely covered with compound. Do not use a nail set to set the nails; use a claw hammer. Strike the nail with the hammer as if you were driving the nail. Use sufficient force in the blow to recess the nailhead below the surface of the sheetrock. This will leave a depression around the nailhead the size of the hammer driving face. Be careful not to hit the nail with such force that the hammer will cut through the manila surface of the sheetrock and into the gypsum core. This destroys the holding power of the nail. With a little practice, you will be able to properly set the nail with one blow of the hammer.

9-30. You may use a putty knife to fill the nailhead depressions with joint cement. To gain some speed, try to develop a skill in using a two-stroke method. The two strokes should form an "X" pattern over the nailhead. Pick up some compound on one side of the putty knife. Make the first stroke downward and at an angle, in a manner which will drag enough cement from the blade to fill the depression. Swing the blade of the knife over and make a second stroke to compress the cement into the depression; at the same time, scrape all excess compound from the surface. (See fig. 36.) You then apply a second and a third coat of compound after each pre-

Figure 35. Feathering a joint.

Figure 36. Covering nailheads.

ceding coat is dry. These coats are usually applied at the same time as the taping and bedding coats. After the final coat is dry, sandpaper the spots lightly to blend them to the surface.

9-31. *Applying stipple.* Sheetrock surfaces will generally have a stipple or texture applied; however, they may be painted without it. The stipple can be applied in any degree from a light, fine texture to a heavy, coarse, decorator pattern. These decorator patterns are usually limited to ceilings in club rooms, or study and den areas in family housing. A fine texture, which resembles a plaster surface, is used in general work areas and offices.

Figure 37. Applying texture with a roller.

9-32. You can apply a light texture with a roller coater, using a stipple cover. Mix the stipple compound, using joint cement and water, to the consistance of thick paint. Pour the mixture into a roller coater pan and use the roller to apply the mixture to the surface. Finish the rolling operation with long, parallel strokes, and avoid leaving ridges or lap marks. Figure 37 illustrates the use of a roller coater to apply a fine texture to the surface.

9-33. Decorator patterns can be created by using such tools as paint brushes, whisk brooms, or sponges. The stipple compound should be of a thick, heavy consistancy. You will probably obtain better results by applying the compound to the surface with a large paint brush. The roller can be used but it may become slick, and slide across the surface rather than spread the compound evenly. Work small areas at a time, by first applying the compound, and then making

Figure 38. Applying a decorator pattern.

the pattern in the compound before it begins to dry. Figure 38 shows the use of a whisk broom to create a decorator pattern on a ceiling surface. When applying these surfaces, make sure the pattern is consistant, and the decorations are uniform in size. All textured surfaces must be allowed to dry thoroughly before you apply the protective coating.

9-34. Painting of new plasterboard surfaces was discussed in paragraphs 4-6 and 4-7 of Chapter 1. The methods used in the repair and repainting of old surfaces was covered in paragraphs 4-9 through 4-11.

9-35. **Coating Interior Masonry Surfaces.** Surfaces of brick or stone are used frequently in interior construction. These may be primarily for decoration, such as planter or flower boxes. They may be functional, such as fireplaces, room dividers, or areas surrounding built-in cooking ovens. These brick or stone surfaces should be

sealed to prevent dusting, especially around eating and cooking areas. Such surfaces, if left unsealed or unpainted, will continue to emit fine dust or sand during their life. These surfaces can be painted with opaque paint, but they are usually sealed with a transparent coating which will enhance their natural beauty.

9-36. You should be sure the surface is absolutely clean before applying a transparent coating. These surfaces can be scrubbed with water and soap to remove grease and dirt films. Always allow the surface to dry thoroughly before applying the coating.

9-37. Use a sealer which is recommended by the manufacturer for masonry surfaces. Sealers of a varnish-solvent base, silicone-water or solvent base, and epoxy are available. You should mix or prepare these sealers by very carefully following the manufacturers instructions. You can apply the sealers by brushing, rolling or spraying; however, brushing usually is recommended. Sealers are generally applied in two or three thin coats rather than one heavy coat. The manufacturer may recommend that solvent-base sealers be heated slightly for the first coat application. Heating will thin the sealer and allow it to better penetrate the pores of the brick or stone.

10. Preparing and Coating Concrete Floors

10-1. Painting concrete floors for decoration is usually not very satisfactory because of rapid wear from traffic. Consideration should be given to covering interior concrete floors with a floor tile, such as asphalt or vinyl asbestos.

10-2. Several types of paint can be used, with varying degrees of success, on concrete floors. A varnish-vehicle floor paint can be used on dry, well-aged, concrete floors. A rubber-base paint will resist alkali and should be used where the concrete is subject to dampness. The rubber-base paint is superior to varnish-base paint in wear resistance, but it will not last with outdoor exposure. Epoxy floor enamel will produce a hard and durable surface on interior or exterior floors, but it is expensive and often difficult to apply.

10-3. **Preparing the Floor.** Concrete floors are prepared for painting much in the same manner as other concrete surfaces. Floors troweled smooth or glazed, should be etched with acid. If alkali or efflorescence are present, the surface must be treated. Above all, the floor must be clean and all traces of oil or grease must be removed.

10-4. Before applying epoxy floor enamel, you should scrub the floor with trisodium phosphate and water. You can sprinkle the dry powder onto a wet floor and use an old straw broom to scour the area. Where heavy oil stains have penetrated the floor, sprinkle the powder heavily over the stain and allow it to remain for 24 hours. The powder will absorb oil from the floor. The floor must be dry before application of the epoxy enamel.

10-5. Epoxy floor enamel comes in two separate containers. You mix it, for use on the job, by mixing equal parts from each container. Mix only enough paint for one coat, as the mixture has a pot life of only 8 to 10 hours. After mixing the paint, it should be allowed to set for 1 hour prior to application. Restir the paint and apply it with a brush. Apply the paint to small areas and brush it out well. Do not overbrush previously painted areas. Allow the first coat to dry for 24 hours. Be sure to clean the brush with a solvent recommended by the manufacturer. Epoxy paint hardens by chemical action and the paint will harden in the brush, even though the brush is left submerged in the solvent. Mix the paint for the second coat as you did for the first coat. Apply the second coat with a brush and allow it to dry. Epoxy floor enamel will dry, to support foot traffic, in 8 hours. It will dry rock-hard in 24 hours, to support heavy machine or vehicular traffic.

10-6. The application of traffic markings will present additional problems to those of painting floors. These markings are subject to heavy vehicular traffic as well as the weather elements.

11. Application of Traffic Markings

11-1. Traffic markings for vehicles are designed and laid out according to military regulations and manuals. While full compliance with the standards is required, post commanders are delegated the authority to determine the degree to which such markings will be used. As a protective coating specialist, it will be your job to apply the traffic markings to runways, taxiways, motor pool parking ramps, streets, curbs, and automobile parking lots. Since the aspect of safety is strongly involved, you will probably coordinate with, and receive guidance from such people as the post safety officer, post law enforcement officer, or post operations officer, as well as your utilities engineer officer. You may receive dimension drawings to follow in applying traffic markings, or you may have to lay out and plan the job. You should follow the current directives carefully whenever they are applicable.

11-2. In some cases, it may be necessary to remove old traffic markings before new markings are applied. The methods commonly used for re-

moving old markings are sandblasting, acid, or caustic washing. Cautious use of heat on concrete is recommended, as excessive heating will damage the surface and may cause steam blowouts from pockets of moisture trapped in the concrete. You should never use heat on bituminous surfaces.

11-3. It is essential that all foreign materials, such as dust, dirt, oil, scale, and other particles, be removed from the surface before marking materials are applied. Dry brushing, brooming, or the use of compressed air is effective. External moisture caused by rain or snow will prevent the proper bonding of the marking materials; therefore you should permit the surfaces to become thoroughly dry before applying the markings.

11-4. **Application of Vehicle Traffic Markings.** There are three types of paint in general use for traffic markings: regular traffic, oil-base paint; plastic, traffic marking paint; and traffic, pigmented binder. The latter type is used in conjunction with glass spheres.

11-5. Traffic, oil-base paint is obtainable in both white and yellow colors. Both paints are intended for application, at a wide range of temperatures, to bituminous and concrete surfaces bearing heavy traffic. You can apply the paints by brush or machine. Certain types of traffic marking machines may require the paint to be thinned. If thinning is required, be sure you use a thinner recommended by the manufacturer. At 70° to 90° F., the paint should set to touch in 30 minutes and should dry to a gloss finish within 1 hour.

11-6. Plastic, traffic marking paint is available in white and yellow colors and comes in powder form. You must apply it with a traffic marking machine, which heats the surface and applies and cures the powder in a single operation. Traffic can be returned to the surface immediately after the paint is applied. Plastic, traffic marking paint has a life expectancy far superior to that of regular oil-base, traffic paint.

11-7. Pigment binder should be applied at the rate of not less than 100 square feet and not more than 110 square feet per gallon. This rate of application will produce a binder film of 0.015 inch thickness. This thickness is necessary to bind the glass spheres and produce maximum reflection and hiding power. You can apply the binder by hand, with a brush, a spray gun, or with a traffic marking machine. When the binder is applied by hand, you must apply the glass spheres to the wet binder with a sphere dispensing gun. The glass spheres should be applied at a rate of 6 pounds per gallon of pigment binder.

11-8. Lane markings for multilane streets are marked with white paint. These should be laid out and painted in a broken line with 15-foot dashes and 10-foot blank spaces. The minimum width of the lines should be 3 inches with a maximum width of 6 inches. The lines should terminate at, and not continue through, intersections. Each of the dashes should be straight and uniform in size. Before you apply the paint, use a string to align the dashes and mark the starting point for each dash location along the line. Use a spot of paint to make the marks, large enough to be seen, when operating the traffic marking machine. When marking the lanes, make sure they are parallel to each other and to the centerline. The centerline on multilane, two-way-traffic streets should be painted yellow. The centerline can be one continuous line, 6 inches wide, or for heavily traveled streets, two parallel lines, not less than 4 inches wide. The parallel centerlines should run not less than 6 inches apart and should be painted with a reflectorized paint. On two-way streets with only one lane of traffic in each direction, the centerline may be painted in a white, broken line similar to the lane markings on multilane streets.

11-9. When painting traffic markings by hand, do not attempt to paint by sight, to a string, or by gaging the width of the markings by the width of a brush or spray pattern. You should obtain or make a marking guide. You can make the guide by fastening two straight boards, parallel to each other with space between the desired width of the line. This guide will enable you to paint uniform in width and with straight edges. Figure 39 illustrates the use of a marking guide when brushing on a traffic marking.

11-10. Automobile parking spaces will require some planning. The act of parking must be simple, trouble-free, and safe. Complicated arrangements only serve to confuse the driver. The driver should be able to drive around effectively

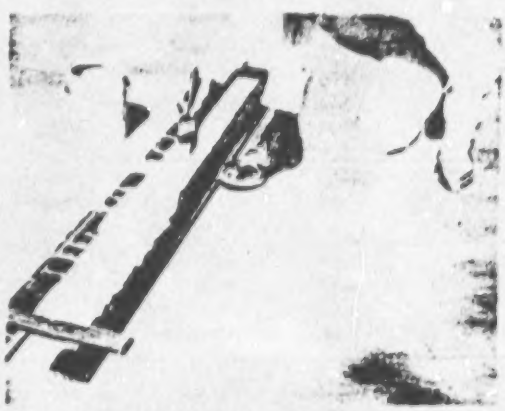

Figure 39. Hand-painting traffic markings.

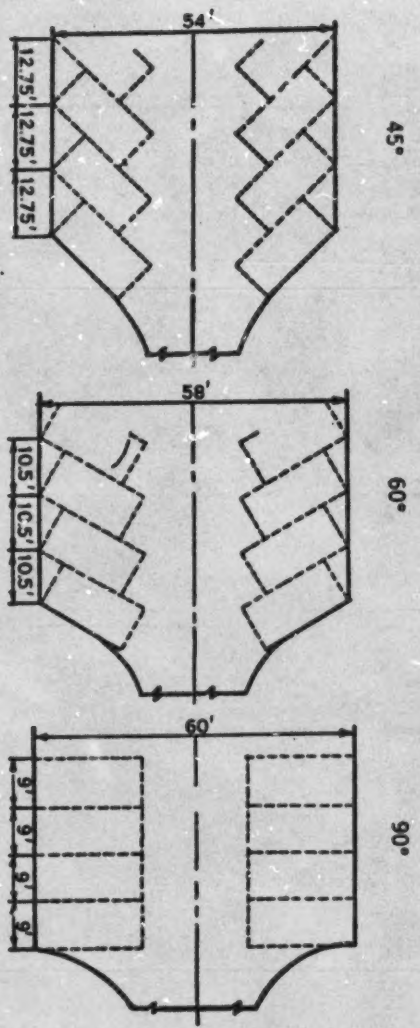

Figure 40. Parking lot layout.

without previous knowledge of the area. The entrance and exit to parking lots should be plainly marked, with pavement directional arrows, as well as signs. Perpendicular or 90° parking may be favored because this arrangement combines economy of space with ease of circulation. It allows for two-way movement with greater safety. Angle parking may be preferred for ease of maneuvering into, and out of, the parking spaces. It is very well suited for movement of traffic in one direction. The angle used, when laying out the markings, depends upon the space available. For recommended widths, refer to figure 40. For 90° patterns, some authorities recommend 65 feet for two lanes of cars. The width will be controlled by available yardage, but 60 feet should be the absolute minimum. When lesser yardage is available, 60° or 45° parking may be used.

11-11. Parallel to street-curb parking is controlled by painting of the curbs. The location of parking positions may be indicated by markings on the pavement. Curbs are painted white to indicate parking areas, and painted yellow to designate no-parking zones. You may apply paint to curbs with a brush or a spray gun.

11-12. Both reflectorized and nonreflectorized traffic paints are available as follows:

a. Alkyd — Relatively slow-dry, nonbleeding.

b. Alkyd-Chlorinated Rubber — Fast-dry, tends to bleed on asphalt.

c. Vinyl Toluene-Butadiene — Fast-dry, nonbleeding.

d. Nonreflectorized traffic paints in a moisture-cure, oil free urethane vehicle for use on indoor floors such as in warehouses and gymnasiums.

11-13. Be sure that paints and pigmented binders are well mixed and uniform before they are applied. If a line striping machine is to be used, test the paint in the machine. Add a small amount of appropriate solvent only if necessary to adjust viscosity for proper application.

11-14. Take care to apply the correct amount of traffic paint to assure that the proper film thickness is obtained. Traffic markings are applied at thicknesses above that of other paints in order to increase their life as the surface is abraded under traffic.

11-15. Mechanical equipment is available in various sizes depending on the area to be covered. The three most common sizes are a small hand-propelled model (fig. 41), a self-propelled model (fig. 42), and a large truck model (fig. 43) to cover large areas such as airfield pavements.

11-16. Reflectorized paint is supplied in two parts in separate containers. One contains the pigmented binder (paint) and the other a measured amount of reflective media. Before the paint sets up, drop the reflective media on the surface of the wet paint so that they are imbedded in the film. Be sure to apply the media uniformly and at the prescribed rate. The reflective glass spheres can also be applied by means of line striping equipment provided with a dispenser which accurately deposits the correct amount of the reflective spheres as the stripe is made, as discussed in paragraph 11-7.

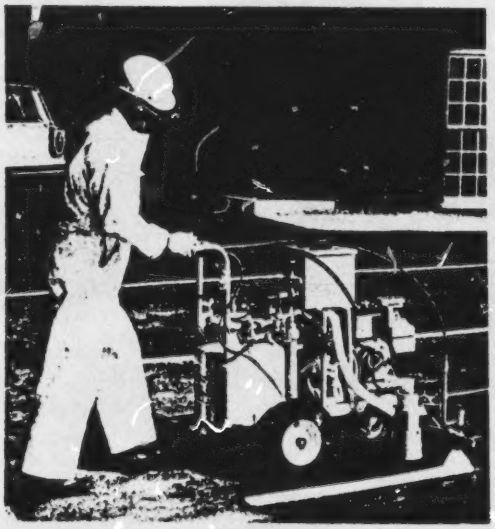

Figure 41. Hand-propelled traffic marker.

Figure 42. Self-propelled traffic marker.

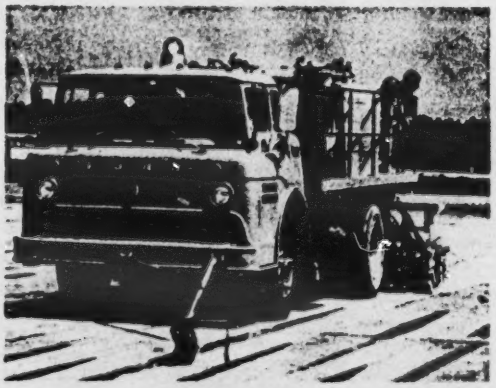

Figure 43. Traffic marker — truck model.

CHAPTER 3

Painting Metal Surfaces

METAL SURFACES, which are to be painted, should be free of scale, rust, corrosion, grease, and other foreign materials. The best coating performance will result from completely clean surfaces, and the most thorough preparation obtainable.

2. In many cases, it is not economical to use extreme meticulous cleaning measures. This can be illustrated by comparing the degree of surface preparation required for atmospheric-exposed steel and that required for steel which is subject to immersion in water. Experience has shown that complete removal down to base metal is generally unnecessary on surfaces subject only to normal atmospheric exposure.

3. As a protective coating specialist, you will have little occasion to protect metal subject to immersion in water, such as boat hulls, or metal locks and gates in river dams. You must have a thorough knowledge of the preparation and coating of structural surfaces subject to atmospheric exposure. The purpose of protective coatings is to prevent the corroding medium from contacting the metal. You must be constantly alert to the visible signs of corrosion. You should be able to identify corrosion as it appears on different metals.

12. Visible Identification of Corrosion

12-1. Both ferrous and nonferrous metals are subject to attack by corrosion. There is no better way of counteracting corrosion than to eliminate it as soon as it is found. The identification of corrosion as it appears to the eye on different metals is explained in the following paragraphs.

12-2. **Steel (Iron).** You may find steel or iron in structures or machinery which has never been treated. This bare metal will rust over its entire surface. The rust can be identified as a red-to-black powder or scale, which may flake off when disturbed. On surfaces which have been primed, the rust condition may be evident only where the primer has been damaged. Any areas on which you suspect corrosion, should be wiped lightly with the tip of your fingers. Rust, if present, will discolor your fingers and produce a reddish stain. If you notice a bubble or raised area on a painted surface, you should be suspicious of corrosion. Remove the raised or loose paint to determine if rust has formed on the metal.

12-3. **Galvanized Iron.** You will find galvanized iron pipe used in most water systems. Normally, corrosion will not attack this metal unless the coating has been destroyed or damaged. Such damage usually occurs in the threaded area of fittings. You can identify this type of corrosion by a white powdery substance on the surface. When wiped off, it will uncover a tarnished area. On galvanized iron used for roofing or siding, rusting will generally be scattered. It will appear as light, white incrustations. When these surfaces are damaged, the galvanized coating will crack, flake, or chip to expose the bare metal to corrosive elements.

12-4. **Nickel or Chrome Plated (Steel).** Generally, you will see nickel- and chrome-plated items used in exposed areas. Since these items are exposed to frequent cleaning and polishing with harsh cleaning solutions or abrasives, they are prime areas for corrosion attack. You identify corrosion on nickel or chrome by small spots on the plated surface. These spots are small pores (openings) in the plating. The corrosion attack, if allowed to continue, enlarges these spots into pits and eventual ruptures.

12-5. **Copper.** Copper is widely used in waterlines, water tanks, and heat exchangers, since fresh water forms a protective coating on it. Copper exposed to the atmosphere slowly develops a thin, protective coating, or patina. The green patina is basic copper sulphate, which is resistant to atmospheric action. You can identify corrosion on copper by its greenish-white color. If the corrosion is the result of acid, it will appear to be more grayish white and quite voluminous. When you observe black spots on painted copper

surfaces corrosion has started. From this start, the dark or black area becomes covered by a green film. Protective paint coatings are not required on copper because of its resistance to corrosion. However, paint may be applied for decorative purposes.

12-6. **Aluminum.** Aluminum and alloys of aluminum are widely used for windows and screens, doors and facings, or roofing and siding. Aluminum produces a tightly adhering oxide film that is highly resistant to corrosion. Normally, aluminum is bright. If you find dull aluminum, check the area for a whitish powdery residue. Where the oxide film is broken, corrosion will have blackened the area and pits will have begun to form. As corrosion progresses, white-gray corrosion will appear on the cut edges or corners. An aluminum surface that has been primed or painted is subject to corrosion wherever there is a scratch or gouge. Moisture trapped under the coating will show as a blister. In the early stages you will see white-gray corrosion in the damaged area. As the corrosion attack continues, the aluminum will appear etched or mottled around the damaged areas.

12-7. Now that you know how to visually identify corrosion on metals, let's discuss the methods used in cleaning corroded areas. The removal of corrosion, as well as grease, oil, dirt, mill scale, or other foreign materials is essential to proper preparation of metal surfaces, prior to application of the protective coating.

13. Preparation of Metal Surfaces

13-1. Cleaning may be by either of two methods: mechanical or chemical. Materials that are heavily contaminated with grease, scale, rust, or dirt should be precleaned to remove the largest amount of surface contaminants. This procedure makes the final cleaning operation more effective and reduces contamination of cleaning solutions with excessive amounts of soil. Mechanical cleaning methods involve the use of brushes, files, grinders, abrasives, sand blasters, steam cleaners, or heat. Chemical cleaning involves the washing or immersing of metals in a solution of acid or alkaline compounds. Mechanical cleaning is sometimes referred to as rough cleaning, and chemical cleaning is referred to as finish cleaning.

13-2. Wet scrubbing with an abrasive scouring powder or detergent, is a good method for removing dirt, oil, or light grease. You should use hot water and a flat, stiff-bristle brush for this operation. If you use wiping cloths, you should change cloths frequently to avoid leaving oil films on the metal surface.

13-3. To remove light to medium scale, you may use a dull chisel, scraper, wire brush, file, or steel wool. In some cleaning, you may use a hammer to break off loose scale and then use a file to smooth out any sharp edges. Hand cleaning is a time-consuming operation and should be limited to small areas which cannot be cleaned by other means. You should use some form of mechanical cleaning for large areas.

13-4. **Mechanical Cleaning.** Mechanical cleaning is determined by the material that requires cleaning, the equipment that is available, the amount of cleaning that is necessary, the space available for cleaning, and the size of the job. No hard-and-fast rules can be laid down; consequently, it is necessary for you to study the problem and select the most suitable procedures.

13-5. On small jobs, precleaning may be done by hand. On large jobs, you may use a steam cleaner to remove oil, grease, or dirt.

13-6. *Steam cleaning.* A steam cleaner consists of such components as an electric motor or small gasoline engine, a water system, a soap system, and a heating system. To operate a steam cleaner, you should follow the operating instructions printed on the data instruction plate. If an operator's handbook is available, read it and become thoroughly familiar with the operating principles of the machine. Always service the cleaner prior to operation. Follow the starting instructions exactly and do not eliminate or skip any of the steps. Once the machine is operating, check the pressure gages frequently to insure proper and safe operation.

13-7. You should not have any difficulty with the cleaning operation. For effective cleaning, hold the nozzle approximately 1 foot from the surface to be cleaned. You should be very careful to prevent splash or overspray from contacting electrical equipment. Water can damage such equipment and it may produce a shock hazard.

13-8. *Power removal.* The use of power-operated handtools is an easy method of rough cleaning and corrosion removal. However, you must be careful when you use power equipment. It is easy to use too much pressure on thin metals, such as exterior siding, or interior partitions. Even when you have the specified brush, grinding wheel, or sander disc, too much pressure can cause damage to the metal by burning or warping. When you use this equipment, wear the proper goggles, face mask, and clothing for self-protection. Take care to properly ground the equipment and not to stand in water or lay the equipment on damp ground.

13-9. Some paint shops are equipped with individual portable power tools, such as grinders,

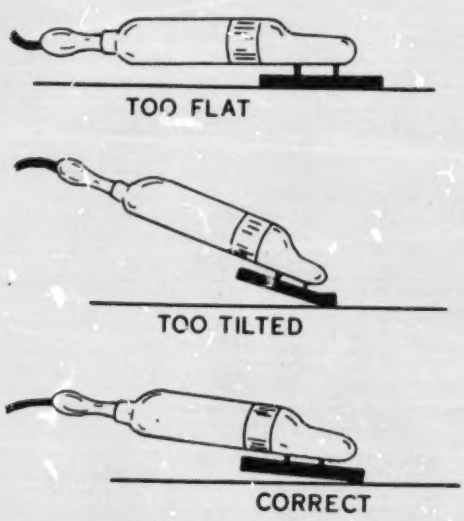

Figure 44. Correct grinder position.

brushes, sanders, and buffers. Other shops may have a universal-type power tool which can be used for any of these cleaning operations. If you install an abrasive grinding wheel, the tool becomes a grinder; if you install a metal brush, and it becomes a power brush. The same tool may be used with a sanding disc as a sander, or a buffing pad as a buffer. The procedure for using the tool is similar for any of these operations.

13-10. *Power brushes.* Power wire brushing will normally result in better surface preparation than hand-brushing. In either case, you will be able to remove only the loose scale and rust. On heavily corroded metal, the bristle cannot reach the bottom of the pits. Hard, tightly adhering corrosion products and mill scale will not be removed. Prolonged application of the wire brush to an area will add little toward better cleaning and will tend to polish the surface. This burnished effect does not produce good adhesion of paint coatings and should be avoided. Generally, a cleaning rate slower than 2 square feet a minute is of little avail toward better cleaning.

13-11. *Power grinders and sanders.* The power grinder is used to remove scale and encrustation. You should use a coarse abrasive wheel to remove heavy deposits by wearing away the corrosion. You would use fine grit-size sanding discs for final dressing or polishing operations. To prevent the grinder from digging into the metal, start the grinder off the metal and lift it from the metal before stopping. Do not lay the unit down while the motor is running. You can obtain the best results by applying moderate pressure as you hold the grinder against the work. You should keep the grinder slightly tilted so that only one side of the disc is in contact with the work. (See fig. 44.) If you apply the entire disc surface to the work, you will feel a "bucking" effect. Excessive pressure will slow down the rotation of the disc and reduce its efficiency. In addition, if the grinder motor works too hard, it draws more electrical current and the motor may overheat. You should move the grinder very slowly over the surface with parallel and slightly overlapping strokes and without burning the metal.

13-12. Since some areas are hard to reach, you may use a flexible shaft to improve the reach of the grinder. Attach one end of the shaft to the grinder and put a disc on the chuck end of the flexible shaft. This attachment makes the unit more efficient without creating any problems. During grinding operations, wear goggles and a face shield because corrosion and grinder particles may break loose and fly off.

13-13. *Chipping tools.* Chipping with hammer-drills or descaler tools is occasionally necessary to remove old, hardpaint coatings, and very heavy, hard rust scale. The use of these impact tools should be controlled so as to not leave sharp, projecting ridges which may become focal points for later corrosion. A hammer-drill

Figure 45. Descaler.

is similar to a regular electric drill motor except it is equipped with a special chuck which produces a chipping or back-and-forth action. You can use special chipping bits in the tool to dislodge heavy scale in bends and corners. A descaler may be operated electrically, or pneumatically, and uses a multiple needle head instead of bits. The head is made up of steel needles held together by a collar. The descaler hammers these needles against the surface to loosen any scale or rust. The descaler is shown in figure 45. You can use this tool to clean inaccessible areas, such as grooves, corners, crevices, rivets, protruding nuts and bolts, and gratings. Grasp the tool firmly, turn it on away from the work, and turn it off while against the work. You should always wear goggles while operating the tool.

13-14. *Abrasive blasting.* Abrasive blasting consists of bombarding a surface with an abrasive at high velocity. This method of cleaning metal surfaces is generally superior to other cleaning processes. Abrasive blasting is a rapid method of removing corrosion and scale from ferrous metal surfaces. The abrasive cleaner is a self-contained unit which supplies its own power from a gasoline engine. The engine furnishes power to drive an air compressor. A hopper provides storage for the abrasive material. A hopper control valve limits the quantity of abrasive used.

13-15. *Abrasives.* Abrasives commonly used for blast cleaning prior to painting are sand, iron shot, and crushed iron grit. The use of the latter two is fairly well restricted to shop work or vacuum blasting, where the abrasive can be reclaimed. It is far too costly for use on field work where considerable loss of abrasive is inevitable. Shot is spherical in form and is not considered as suitable as crushed steel grit for surface preparation prior to painting, since the rounded shot tends to work the metal and is less effective in etching the surface. Sand is quite readily available in most localities and is an excellent abrasive for field blast cleaning work. The sand used for blasting surfaces preparatory to application of paint systems should be free of clay and dust. It should be composed of hard grains and of such particle size as to be passed by the 20- and retained on the 50-mesh sieve (U.S. Standard sieves). Although sand graded between these sieve sizes is very efficient in blasting rate and produces a desirable anchor pattern for coatings of average thickness, the graduation should not be adhered to slavishly if economies can be effected by procuring sand with a somewhat greater range of particle size. For example, 10 percent larger than the No. 20 sieve or the same percentage smaller than the No. 50 sieve does not reduce the efficiency of a blasting sand sufficiently to preclude its use. Of course, these outsize fractions should be controlled sufficiently to prevent unworkably large particles at one end of the scale and dust at the other.

13-16. *Blasting nozzles.* The abrasive is directed to the surface being cleaned, by hose and a blasting nozzle. The nozzle has a control valve to start or stop the air pressure and abrasive flow. A large variety of nozzles are manufactured for sandblasting work. Nozzles are made of ceramic material, cast iron, various steel alloys, or tungsten carbide. The number of hours of blasting obtained from one type varies greatly from that obtained from another. When reference is made to the type of materials, the reference is made to the lining area of the nozzle, or that area which is in contact with the air and sand during use. A quick reference to the life expectancy of nozzles is as follows:

a. Ceramic nozzles which have a life of from 1 to 2 hours.

b. Cast iron nozzles which have a life of from 6 to 8 hours.

c. Tungsten carbide nozzles which have a life of approximately 300 hours.

d. Norbide nozzles which have a life of approximately 750 to 1000 hours.

The hourly life figures given above are for sand. If steel grit is used as the abrasive, the life would be 2½ times greater.

13-17. *Operating the sandblaster.* Most units have a battery and starter for easy starting. You should check the fuel tank and water radiator for an adequate quantity and the engine and compressor for an adequate supply of oil, as shown by the dipstick. You should check the abrasive hopper supply control to make sure that it is in the closed position. (It should have been closed before the last shutdown or during refill of the hopper.) You start the engine by turning the switch to the START position. You check the oil pressure gage to make sure that the indicator is in the safe area and allow the engine to build up air pressure (100 psi), which is controlled automatically by a governor. At this point, you should put on your protective clothing and helmet. Uncoil the abrasive hose, and while holding the nozzle, set the hopper supply control to the half-open position. Now you are ready to begin the cleaning process. Notice that the airman in figure 46 is holding the nozzle in the correct position—ready to clean the part. He can start the cleaning operation by opening the

Figure 46. Sandblaster.

nozzle control valve. When you open the nozzle valve, air is expelled and the abrasive is fed from the hopper. The air pressure bombards the surface with the abrasive at high velocity. You can stop the cleaning by closing the hopper control valve. After all the abrasive has cleared the nozzle, close the nozzle valve. Now, if you have finished your cleaning, shut off the engine. After the engine has stopped, bleed off the air pressure in the tank by opening the nozzle control valve.

13-18. To effectively use the abrasive cleaner, you should hold the nozzle between 12 and 18 inches from the surface to be cleaned and at a slight angle from perpendicular. The greatest abrasive impact is obtained with the nozzle perpendicular to the surface, but the rebounding particles interfere with the abrasive coming from the nozzle and reduce efficiency. The customary blasting pressure for structural steel work is in the neighborhood of 80–100 psi. For steel of small cross section and for lightweight metals, the air pressure should be reduced to avoid excessive deformation. The normal pressure used for sandblasting brick and mortar surfaces is 40 to 60 psi.

13-19. Any degree of cleanliness of steel surfaces can be obtained by blast cleaning, depending on the time you spend on the work. These grades of blast cleaning have been set up as standard practice, and these are used to describe or control the degree of cleaning desired on a particular job. The three grades of blast cleaning are explained as follows:

a. White Metal Blast Cleaning. This classification covers complete removal of all corrosion products, all mill scale, all paint, and all other foreign matter from the surface of the metal. The end result is a light gray steel surface of uniform appearance with a good anchor pattern for strong adhesion of a protective coating.

b. Commercial blast cleaning. This classification demands a good but not perfect blasting job and includes the removal of practically all rust, mill scale, and other foreign matter from the surface of the metal. The surface will not necessarily be uniform in cleanliness and appearance. This grade of blasting will also produce an anchor pattern suitable for bonding applied coatings.

c. Brushoff blast cleaning. This classification requires only the removal of all loose rust and all loose mill scale. Tight mill scale and minor amounts of adherent rust and old paint are permitted to remain on the surface. The surfaces are sufficiently roughened by the blasting to provide a good anchor for paint coatings.

13-20. Regardless of the type of sandblasting you use, dirt and grit from the cleaning process should be removed from the surface before you do any painting. A vacuum cleaner can be used for this clean-up operation. It is also important that you paint as soon as practicable after cleaning. A freshly blasted surface is susceptible to rusting, especially in humid atmosphere.

13-21. *Flame cleaning.* Flame cleaning is used on steel to loosen scale before wire brushing and to dehydrate the metal surface. To use this method of cleaning, you must have oxyacetylene gas, flexible hose, a burner head, and a wire brush. The oxyacetylene burner head has a series of small, closely spaced holes that project the flame at high velocity. For flat surfaces, use a burner head with a row of small openings that produce brush like flames. To clean riveteads, corners, and areas not easily accessible, you would use a burner head that produces a circular group of flames. The heat of the flame reduces the metal's surface rust to powdered, black oxide of iron, and pops off loose mill scale through the sudden differential expansion caused by the heat. Immediately after you remove the flame from the metal, you should wire brush the heated surface to remove all loose particles and rust.

13-22. Before you operate the flame cleaner, you need a pair of heavy gloves and a pair of safety glasses. Then find a fire extinguisher and set it near your work area. Now, holding the burner head, slightly open the oxyacetylene valve

and ignite the gas flowing from the burner head. After the gas has ignited, open the gas valve until you get small, brushlike flames about 2 to 3 inches long. You should pass the flame over the surface being cleaned at an angle of 45°. The heat removes or loosens loose mill scale and causes any moisture beneath the scale to vaporize. The oxyacetylene flame will burn oil, grease, and paint; but because of their slow rate of combustion, it is inefficient for the removal of such materials. You should not prolong the heating because it may cause warping of the base metal surfaces. You will discover that the flame heating loosens and pops off some scale and corrosion, but the wire-brushing you do after the flame heating does most of the cleaning. To shut off the flame, simply close the oxyacetylene valve. Be careful not to place the hot burner where it may cause a fire.

13-23. You have learned the types and methods used in rough, or mechanical cleaning of metal surfaces. Now, let's discuss chemical, or finish, cleaning of metals.

13-24. **Chemical Cleaning.** There are two techniques used in chemical cleaning of metals: the brush-on technique and the immersion technique. The brush-on technique can be used in the field for certain mild chemical applications. The immersion technique is reserved for shop use and only then when the shop is properly equipped. This includes immersion tanks which can be heated, overhead chain hoists for handling items during cleaning, and wash and drying racks.

13-25. *Ferrous metals.* The chemical rust removers that are used on ferrous metals (iron and steel) are of the acid and alkaline type. The purpose of the acid type is to remove red rust and black oxide formations by either immersion or brush application of the chemical. The alkali type is intended for removing red rust by immersion treatment.

a. Acid-type corrosion removers. Phosphoric acid-type, corrosion remover, Specification MIL–M–10578, type III, is used to remove corrosion from ferrous metal surfaces. The remover not only gets rid of the rust, it also conditions the surface prior to painting. Before you use the acid-type corrosion remover, you should provide protection for the adjacent components and parts and remove any grease or soil that might be on the area or part. If heavy rust is present, you can remove most of it by chipping, or brushing the area with a wire brush. After you properly dilute the remover with one part of the concentrated remover to one part of water by volume, you can apply it to the corroded area with a brush or swab. The remover should remain on the corroded area long enough to loosen the rust. The time, 2 to 10 minues, will vary according to the degree of rusting. You can remove the remover by rinsing, preferably with hot water. After completely rinsing the part, dry it and immediately apply the protective paint or corrosion preventive finish.

b. Alkali-type corrosion removers. You can remove corrosion from small parts by immersing the parts in a sodium-hydroxide-base, corrosion-removing compound, Specification MIL–C–14460, type I. The compound will remove grease, paint, and rust from the parts. The compound can also be used to clean brass and copper, to strip phosphate coatings, and to remove rust from critical or machined surfaces without causing dimensional change of the part. However, do not use the solution to remove corrosion from aluminum or a joint where dissimilar metals meet. The rust removal time will vary according to the extent of the rust. After the part has been cleaned, you should rinse it thoroughly with hot water, dry it, and apply a final protective finish.

13-26. *Stainless steel.* You can clean rust and scale from stainless steel with a mixture of 12 ounces of sulfuric acid per gallon of water. The water should be at least 180° F., and the solution should be used very liberally. If this solution does not clean the material, prepare a solution as follows:

Nitric acid	50% by volume
Hydrofluoric acid	5% by volume
Water	45% by volume

This solution should have a temperature of 60° F. to 100° F. If possible, you should submerge the material in the solution. You should continue this treatment for no more than 45 minutes, because a longer period is not any more effective. Next, you rinse the material being cleaned in clear water and immediately passivate the surface by applying a solution of 50-percent nitric acid and 50-percent water, by volume. After you have passivated the material, you should again thoroughly wash it in clear water.

13-27. *Carbon steel.* You can clean carbon steel with a 50-percent hydrochloric acid and 50-percent water solution, by volume. The solution does not have to be heated, but the cleaning should be continued until the material has been cleaned of corrosion. After cleaning the material, you should thoroughly rinse it in clear water and allow it to drain for not over 5 minutes. At this time, you must flush the material with a 0.01-percent nitric acid solution. Following this treatment, again thoroughly rinse the material in clear water and allow it to dry.

13-28. *Aluminum and aluminum alloys.* You can clean aluminum and aluminum alloys by using the same type solutions and mixtures used for stainless steel. If you have used tanks for the solution and cleaned steel in the tanks, the same solution mixture cannot be used for aluminum. The chemical reaction of the solution and steel is damaging to aluminum. After you have cleaned the aluminum, rinse it in a solution of clear water.

13-29. *Copper and copper alloys.* You can chemically clean copper and copper alloys in 18-percent hydrochioric acid or 10-percent sulfuric acid, by volume. You wash the material with the solution for 2 to 3 minutes and then scrub with a bristle brush. You may repeat the procedure until the desired cleaning condition is obtained. After cleaning, water-rinse the material until you have thoroughly removed all trace of the acids.

13-30. Until you become proficient in handling chemicals, your supervisor will delegate a qualified individual to be in charge of any cleaning operation. The individual in charge will insure the proper selection, preparation, and use of treating equipment and materials required for the cleaning operation. After you have shown that you can do the work safely, you may do it alone, or you may be put in charge of another man who is new at the cleaning job.

13-31. Whenever you use chemicals for corrosion removal, be extremely cautious before, during, and after the process. Before cleaning metal with strong solutions, you must have suitable protective clothing and equipment and you must properly prepare the solution you are going to use. Be careful not to splash or spray the solutions on the surroundings. When a solution becomes dirty, the results of the cleaning process are unsatisfactory, or the cleaning time becomes lengthy, prepare new solutions. After you have drained tanks and drain trays, thoroughly clean them by flushing with water and scrubbing with a fiber bristle brush. Be prepared to catch or trap all of the chemical discharge solutions, because they may damage the sewer system or pollute nearby streams or ribers. If your post has an industrial waste disposal facility, label the waste containers according to their contents and separate them from trash for proper disposal. If your post does not have this type of waste disposal, you should transport the waste containers to the sanitary fill for burial. Overall, your use of chemicals for corrosion removal will be very limited; but now you know what you can do, how it is done, and the result that can be obtained by using chemicals.

14. Repair of Metal Surfaces

14-1. As a protective coating specialist, it will be your job to make minor repairs to metal structures, prior to painting or repainting. The repairs that you make will be limited in scope, but they may be the most important repairs ever made to the building. Whenever the paint is renewed, it provides an occasion for making minor repairs that otherwise might be neglected until they become major repairs. Since corrosion effects differ according to the metal usage, we will discuss repair in reference to where the damage is found.

14-2. **Structural Steel.** Heavy steel framing is used in many major military buildings and structures. Your work in this area is limited to corrosion prevention by painting. The repair of structural failures or damage to heavy steel framing must be done under the supervision of a structural engineer. The work is generally accomplished by contract.

14-3. You will find steel used for framing around openings for windows and doors, interior wall partitions, and other purposes. Generally, the emphasis placed on visible structural steel is appearance and the steel will have been painted. Corrosion may be found wherever the paint has deteriorated or shows blistering. You can remove small areas of corrosion from such surfaces by wire brushing. After you have removed all evidence of corrosion, spot-prime the area and apply one or two overall coats of matching paint.

14-4. In interior or unseen areas, such as steel framing that supports dropped ceilings, you may be concerned with eliminating corrosion caused by roof leaks, water piping leaks, or condensation. You would remove the corrosion by wire brushing and finish the surfaces with a primer coat. You should also eliminate the source of moisture or report it to the utilities shop.

14-5. **Metal siding.** Metal siding is manufactured from aluminum, galvanized iron and steel, or black iron. It may be "V" crimp or it may have half-oval or half-square corrugations to give it rigidity. It may be formed to have the appearance of wood siding. The corrogated sheets are generally installed with the corrogations running vertically. The types which resemble wood siding are usually installed horizontally. Some aluminum siding and most black-iron siding will have a factory-applied protective coating. This may be simply a baked-on enamel finish, or it may be a protective coating designed to meet the most severe applications. A sheet of protected corrugated metal siding is illustrated in figure 47.

14-6. Before repairing, touching up, or recoating protected metal siding, you should clean the area. Remove all loose or torn asbestos felt,

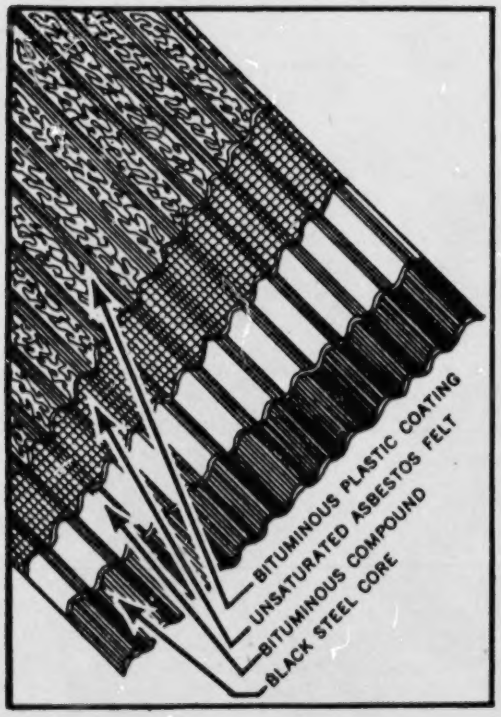

Figure 47. Protected metal siding.

flaked coating, and rust with a stiff fiber brush. To remove grease, dirt, or chemical deposits, use soap or a detergent cleaner. You may use solvents to soften or disolve bituminous compounds. To repair small bare metal areas, follow these steps:

a. Clean the area and remove any rust with a wire brush. Coat the exposed metal, plus 1 inch of the adjoining asbestos felt and bituminous covered surfaces, with asphalt primer.

b. Allow the primer to dry for at least 24 hours and then apply bituminous plastic cement until you form the continuous plane with the original adjoining surfaces.

c. Allow the cement to set for 24 hours, and then apply a brush coating of bituminous compound, overlapping the adjoining surfaces about 1 inch.

14-7. When only the asbestos felt is exposed at a damaged area, repair it. For this repair, apply a brush coat of bituminous compound. After this coat has dried at least 24 hours, apply a final coat of the same compound.

14-8. Before painting or repainting galvanized or aluminum siding, check all bolts, clips, nails, and other ties and fasteners for being in place and tight. If any panels have physical damage, such as cuts, breaks, or cracks, replace them with matching material. If the siding section is repairable, you may remove it, straighten any bends, and replace it. You may discover rusted or loosened bolts and screwheads. When you cannot correct this situation by using new bolts or screws, drill the necessary new holes in an adjointing solid portion of the siding. Use stainless steel sheet metal screws for fastening siding sheets to each other and use stainless steel self-tapping screws to fasten sheets to structural steel. To fasten siding to wood framing, use stainless steel nails with lead-covered heads on galvanized iron, and use aluminum nails with neoprene washers on aluminum. When locating fasteners on corrugated siding, place them on top of the corrugation and not in the valley. Do not tighten them to the extent that the shape of the siding will be deformed.

14-9. **Dissimilar Metals.** You have already learned that whenever two or more dissimilar metals are in contact and moisture is present, corrosion develops rapidly. You may find this condition to exist when you are painting metal gutter and flushings, or piping. The treatment of dissimilar metals consists of three steps:

(1) Determine the type of metals involved.
(2) Clean any corrosion damage caused by the contact of the metals.
(3) Seal the surface area of each piece of metal to exclude moisture and insulate against an electrical circuit, when the metals are rejoined.

14-10. When a fastener is made of different material from the material to which it is attached, remove the fastener and coat it completely with one heavy coat of zinc chromate or inorganic zinc dust primer. Reinstall the fastener while the primer is still wet. If available, a fastener of the same material as the rest of the part should be used when replacement is necessary. Cadmium-plated fasteners are considered satisfactory for joining to aluminum.

14-11. When a pipe, tube, or some other metal part is clamped tightly to a dissimilar metal, loosen the clamps so that the pipe or tube may be moved away from the dissimilar metal. Paint the pipe, tube or other metal part, and the dissimilar metal at all points in which the metals touch, with zinc-chromate primer. Reassemble the fittings and piping and finish with two coats of synthetic enamel.

14-12. **Dents, Scratches, and Small Holes.** You should repair all small surface defects prior to painting or repainting metal surfaces. The time you spend in such repairs will not only add to

the retardation of corrosion at the damaged areas, but will add greatly to the appearance of the finished surface. In most cases, it will be important that you repair holes in metal surfaces to prevent water leaks. There are several types of metal filler and putty which you can use to repair these small surface defects.

14-13. *Body filler.* Body filler, of the type commonly used commercially in auto body repair and paint shops, can be used to repair dents, holes, and leaks in metal surfaces. You should clean the metal and then mold or shape the filler to the surface contour as you apply it. The filler will dry rock-hard in 4 to 6 hours. After it dries, smooth and feather it by using files, abrasive grinders, or by sanding.

14-14. *Engraving filler.* Engraving filler gets its name because it is used for filling stamped or engraved markings on metal, ceramic, and plastic surfaces. You can use this type of filler to fill deep scratches where no denting is involved on metal surfaces. It hardens with very little shrinkage. After it has dried, you can sand off the excess filler to provide a smooth surface with the original metal. You can use the filler equally as well on painted metal surfaces which have been scratched. Do not sand the scratched area prior to applying the filler. After the filler had dried, wet-sand the area lightly to blend into the painted surface.

14-15. *Plastic paste filler.* Plastic paste fillers have the advantage of a rapid drying time, but they are more difficult to apply. You must mix the ingredients immediately prior to applying the filler, which comes packaged in two containers. The catalyst powder must be added to the liquid filler to cause it to harden. Once the ingredients have been mixed, you must work hurriedly to fill the dents, holes, or cracks as the filler will set and completely harden in 20 minutes. The damaged area should be cleaned and ready for application of the filler prior to mixing the ingredients. After the filler has hardened, you can sand it to conform to the surface and then prime or paint the area as required.

14-16. You may find holes as large as 1 to 2 inches in diameter in metal siding where piping or electrical conduit has been removed. If the surface is flat, you may repair the hole by cutting and installing a metal patch with sheet metal screws. On corrugated surfaces, you can apply a muslin cloth, or fiberglass patch. Banana-oil-base glue, aircraft dope, or plastic paste filler can be used as an adhesive for applying the patch. Completely coat the surface of the patch with the adhesive to give it body and strength. After it has dried, prime or paint to match the surrounding surface.

15. Metal Conditioning and Pretreatment

15-1. Metal surfaces, which will be subjected to severe or extreme exposure conditions, may require a pretreatment prior to application of the protective coating. This pretreatment should not be confused with the priming of the metal, nor should it be considered as a cleaning process. The pretreatment is necessary to improve or cause adhesion of the protective coating to the metal. There are two types of pretreatment which you may use in the painting of Air Force metal buildings and structures: a chemical metal conditioner, and a vinyl wash coat treatment.

15-2. **Chemical Metal Conditioner.** This material is a mixture of phosphoric acid, wetting agents, water-soluble oil solvents, and water. It is available under Military Specification MIL–M–10578A, type II, or it may be purchased locally in a concentrated solution. The solution requires dilution in the proportion of three parts of water, by volume, to one part of conditioner. This should produce an acid concentration of 5 to 7 percent by weight.

15-3. The compound is easily applied with a whitewash brush. You should work the conditioner into the pits, around fasteners, and bolt-heads, and other irregular surfaces. It can also be applied by spray, but the brush method is preferred to assure intimate contact of the liquid with the metal, and to avoid the use of excessive amounts.

15-4. After the conditioner is applied to a surface, the acid will react with the metal. When a dry powdery surface, grayish-white in color develops within a few minutes after application, the acid has reacted properly and has the proper dilution. If a dark color develops and the surface is somewhat sticky, the acid is too concentrated. In such cases, you may wipe the surface with a water-dampened rag to bring about the desired appearance. It is sometimes necessary, in order to obtain the proper reaction, to use one concentration on warm surfaces in direct sunlight and a different concentration on shaded areas. Surfaces which generally do not show the gray powdery reaction should be retreated, but the fact that every square inch of a large area does not react, should not cause alarm. Treated surfaces usually present a somewhat mottled appearance.

15-5. The conditioner is not recommended for use on structural steel unless it has been sandblasted. Poorly cleaned areas, mill scale, and other foreign material will cause the acid to react differently on each area. The conditioner is not recommended for touchup work because the

plaint surrounding the area being repaired may be damaged by the acid in the conditioner.

15-6. **Vinyl Wash Coat.** This wash coat material is procured under Military Specification MIL–C–15328A, Coating, Pretreatment for Metals. It is popularly known as WP–1 or as formula No. 117 for metals. It comes packaged as two separate components which are a base resin solution and an acid diluent. The components must be very carefully mixed just prior to use, by adding one volume of the acid component to four volumes of the resin component. Slowly add the acid component to the resin component and stir constantly while doing it. If the acid is added too rapidly, without thorough mixing, or if the base solution is poured into the acid, the mixture will gel and be unusable.

15-7. The wash-coat material is suitable for application by spraying. You should apply it at a coverage rate of 250 to 300 square feet per gallon. This should produce a thin but continuous film of 0.3- to 0.5-mil dry film thickness. You should not apply more than 0.5-mil thickness under any circumstances. When dry, the coating should be thick enough to give a continuous film, but should not be so heavy as to completely hide the underlying metal. The base metal should show faintly through the dry film. It is important that the wash-coat solution be applied within 8 hours after mixing, even though its condition appears satisfactory after the time limit has expired.

15-8. You should not apply the wash coat over visibly wet surfaces, because the wash coat may dry on top of the water film without absorbing it, and poor adhesion to the base metal will be the result. The applied film may turn white and be lacking in strength and distensibility. If the wash coat must be applied to damp surfaces, you should apply it by brush or swab. This will break up and incorporate the moisture. Although the wash coat is more adaptable to spraying, it can be brushed or swabbed on without difficulty.

15-9. If the spray does not deposit a wet, uniform film during application, you should thin the wash coat solution with either 99 percent isopropanol or normal butanol. You will find that more thinning will be required in very warm, windy weather than under more moderate conditions. Spray equipment should be cleaned as soon as practicable after use with butanol, 99-percent isopropanol, or denatured ethyl alcohol. Wash coat materials will form insoluble gels after the mixture has stood more than 8 hours. Wash coat material which has gelled in spray lines is practically impossible to remove.

15-10. Dry films of vinyl wash coat may undergo some color change. The end color after a 24-hour drying period may vary with weather conditions or thickness. The fact that the dry film does not always exhibit exactly the same appearance, should not cause concern. Subsequent coats of primer or paint may be applied after 1 hour of drying of the wash coat. Longer periods of drying, up to several days, are permissible as long as damage to the wash coat film from corrosion or other causes has not taken place.

16. Application of Protective Coatings

16-1. Metal surfaces must be painted as soon as possible after they have been prepared. If the surfaces are allowed to corrode again, they must be recleaned before the paint is applied. You can apply paint to metal surfaces by brushing, rolling, spraying, flowing, or dipping.

16-2. **Dip or Flow-Coat Method.** The dip or flow-coat method is used for volume production painting of certain items that are suitable for these painting methods. When you use the dip method, have a tank to hold the paint. The paint in the dip tank is maintained at a constant temperature and agitated frequently to assure uniformity of the paint. Check the viscosity of the paint at regular intervals, and add more solvent when required to replace the volatile solvent that has evaporated. These precautions are necessary to obtain a uniform paint film thickness on the items dipped. Flow coating differs from dipping that the paint is flowed over the item to be painted; as the surplus paint flows off the item, it is caught in a tank or trough from which it is recirculated by pumps.

16-3. **Roller Coating.** Roller coating is a fast, economical, hand method of painting large areas. It works as well on metal as on wood or masonry surfaces and is applied in the same way on each. The amount of pressure regulates the quantity of paint transferred from the fabric on the roller to the surface being painted. Metal usually takes less paint because it does not absorb as other surfaces do. Thick fabric rollers, such as those used for rough plaster or cinder block are also best used when painting chain link fences, wire grills, or roughened metal.

16-4. **Brush Method.** Usually, protective coatings are applied to metal surfaces with a brush when the volume of work does not justify setting up spray apparatus or when equipment is not available or is inaccessible to the job. The task of masking out parts to remain unpainted is extensive when the mist from the spray gun will damage equipment in the surrounding area or create a fire hazard. When the brush method is used to apply coatings on metal surfaces, it is per-

formed in the same manner as for wooden surfaces.

16-5. **Spray Application.** The easiest and fastest method of applying protective coatings to large metal surface areas is to spray them on. The coating material that you are going to use should be strained to remove all particles that might clog the spray gun. This is especially important when the material comes from a previously opened container. Follow the thinning directions on the container to be sure of the proper viscosity for applying the spray. Viscosity may be defined as a fluid's internal resistance to flow. Fluids of low viscosity are thin and flow freely; fluids of high viscosity are thicker and flow slowly. The viscosity of a paint makes a significant difference in the ease or difficulty of its application, especially if it is applied as a spray. Normally, the viscosity has little direct effect on film properties because it is a ratio of the thinner versus the paint, and the thinner will evaporate in drying. However, you must be concerned because viscosity control is essential to obtain consistent results in application. Too low a viscosity leads to runs or sags. A primer too low in viscosity and too thinly applied leads to blushing and too high viscosity may cause orange-peel effects, excessive film thickness, or dusting. For consistent coating results, the viscosity of each coating mixture must be controlled.

16-6. *Viscosity measurements.* Viscosity is measured by various methods and instruments and is expressed in various units of measurement. The two methods most frequently cited in the coating industry use either the Ford or the Zahn viscometer cups. The viscosity is expressed in seconds through the cup. The seconds indicate the length of time it takes at a given temperature for a known quantity (cup filled to the top) of the coating material to flow through a certain size orifice in the cup. For example, viscosities at 77° Fahrenheit of 16 to 22 seconds through a No. 4 Ford cup, or 19 to 27 seconds through a No. 2 Zahn cup are generally right for spraying enamels. Lacquers will require about 4 seconds less in either cup. For comparison, the viscosity of water and some thinners is 10 seconds through a No. 4 Ford cup. The Zahn cup is usually considered the standard and most appropriate for field use.

16-7. *Zahn cup.* The Zahn cup is designed to measure the viscosity of fluids directly from their containers. It consists of a 44-mil cup with a hole (orifice) and a wire handle, as shown in figure 48. Fill the cup by immersing it in the fluid; then time the flow of the paint through the orifice from the second the cup is withdrawn from the paint being tested to first interruption in the flow.

16-8. In Memorandum 562, we discussed the different types of paint spray equipment, but did not go into the instructions on how they were to be operated. Now, let's learn how to use them. Since the air-atomized spray is the most common type used on buildings and structures, we will discuss it first.

16-9. *Air-atomized spray.* Before starting to spray paint, you should check the adjustment of the spray gun. There are adjustments for various purposes: for example, to control the air pressure and flow of material and to provide a means of changing the direction of a spray pattern. For a low-pressure spray gun, the air pressure should be between 20 and 40 psi, for a high-pressure gun between 80 and 100 psi.

16-10. The proper air pressure is essential to a good spray job. Too high an atomization pressure will thin out the center of a spray pattern. As too little air pressure will fail to atomize the material sufficiently; a coarse, spattered effect, that is unacceptable, will be the result. This ad-

Figure 48. Zahn cup.

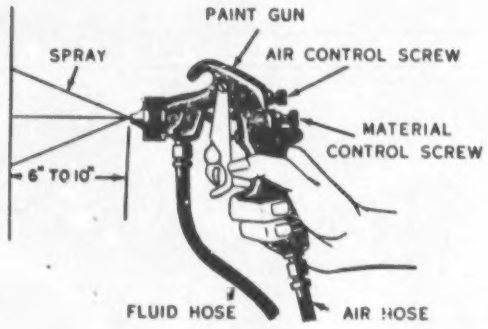

Figure 49. Holding spray gun correctly.

justment can be checked most satisfactorily by studying the spray pattern made by the gun. Such an adjustment may be made with the air control screw located above the handgrip shown in figure 49.

16-11. The speed of operation at which you move the gun across the surface being painted determines how you adjust the flow of material from the gun nozzle. An experimental period in which you use various settings of the adjustments will be of value in determining the most efficient operation. The adjustment should permit a comfortable, rapid stroke with sufficient coverage without runs and sags. The flow of materials is controlled by the material control screw also located above the handgrip in figure 49.

16-12. The direction of a spray pattern may be changed by rotating the spray gun cap or air nozzle. In this manner, it is possible to produce a spray pattern about 6 to 8 inches wide when the gun is held 6 to 10 inches from the surface.

16-13. *Spray gun stroke.* You should hold the spray gun perpendicular to the surface, as illustrated in figure 49. Tilting the gun up or down gives an uneven spray pattern. The distance of the spray cap or nozzle from the surface will depend upon the air pressure used and the consistency of the paint. Generally, the distance varies from 6 to 10 inches. Holding the spray gun at a greater distance causes a dry spray and excessive spray dust. The trigger controls the action of the gun. The farther the trigger is drawn back, the greater the flow of material.

16-14. Move the spray gun with straight, uniform strokes backwards and forwards across the surface in such a way that the spray pattern will overlap about 50 percent of the previous stroke. Use a free arm motion and feather-cut the end of each stroke. You do this by pulling the trigger after beginning the stroke and releasing it before the stroke is completed. Caution should be taken not to arc the gun, since this causes an uneven deposit of paint and excessive overspray at the end of each stroke. Figure 50 illustrates a proper spray gun stroke as well as an incorrect stroke.

16-15. When you feel that you can operate a spray gun properly, practice spraying on old cartons or on sheets of paper tacked to a wall or box. After practicing for about 15 to 20 minutes, you will get the feel of the gun and acquire enough confidence to do actual spray painting.

16-16. *Spraying a panel.* Panels may be sprayed by using horizontal or vertical spray gun strokes. To spray a panel with horizontal strokes, follow the procedure illustrated in figure 51.

16-17. The work is started with a dry stroke, that is, with the trigger released, a few inches to the left of the panel. The trigger is pulled at the instant the gun nozzle is opposite the left edge of the panel. The gun is aimed at the top edge of the panel as the stroke is being continued across it. The trigger is released the instant the gun nozzle is opposite the right edge of the panel. The dry stroke is continued a few inches before reversing for the second stroke. When the gun nozzle is opposite the right edge of the panel, the trigger is pulled, but this time the nozzle of the gun is aimed at the bottom of the first stroke. In this manner the second stroke will overlap the first stroke about one-half. This system gives a double coverage to a surface and assures a full wet coat without streaks. A half overlaping stroke is usually used for all work. Continue with right and left strokes until the panel is completed.

16-18. In some cases, in order to reduce overspray at the right and left ends of a panel, you may use a banding technique. This procedure calls for single vertical strokes at each end of the panel, as shown in figure 52.

16-19. Banding assures complete coverage and saves the paint which is normally wasted as a result of your trying to spray right up to the vertical edge with horizontal strokes. The top and bottom of the panel are sprayed with horizontal strokes

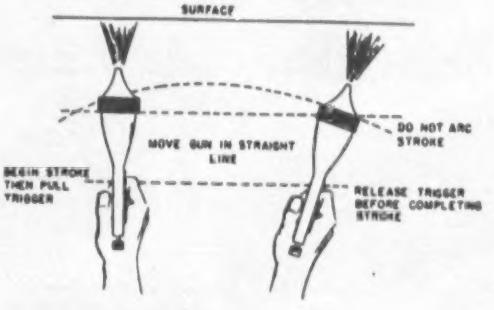
SURFACE
DO NOT ARC STROKE
MOVE GUN IN STRAIGHT LINE
BEGIN STROKE THEN PULL TRIGGER
RELEASE TRIGGER BEFORE COMPLETING STROKE

Figure 50. Spray gun strokes.

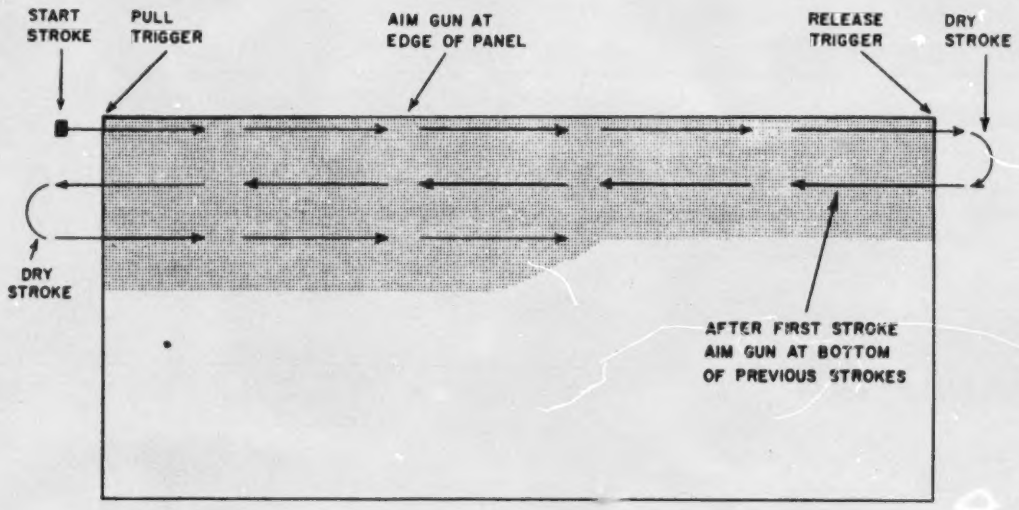

Figure 51. Spraying a panel.

aimed at the edges of the panel. These strokes automatically become banding strokes. The panel is then finished with horizontal strokes.

16-20. Long panels may be sprayed with vertical strokes, as illustrated at the top of figure 53. Sometimes this procedure is best, since stroke-end laps are avoided. However, most experienced sprayers prefer the horizontal stroke to the vertical stroke, since spraying with a horizontal stroke is more natural. Such operators, because of their experience, are able to make an excellent job with invisible overlaps. Painting a panel with horizontal strokes is shown at the bottom of figure 53.

16-21. *Spraying edges.* When the edges, as well as the face of a panel, are to be sprayed, a modified banding technique is used. A single stroke along the edges paints the edges and bands the face of the panel at the same time.

16-22. Outside corners are sprayed in the same manner. In such cases, the gun is aimed at the corner and the spray coats both adjoining surfaces with one stroke of the gun, as shown in figure 54.

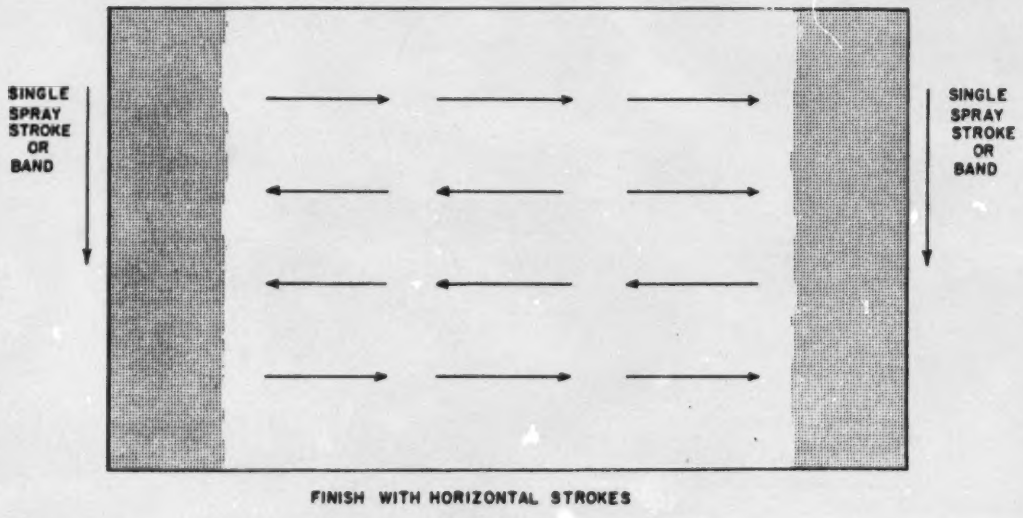

Figure 52. Banding a panel.

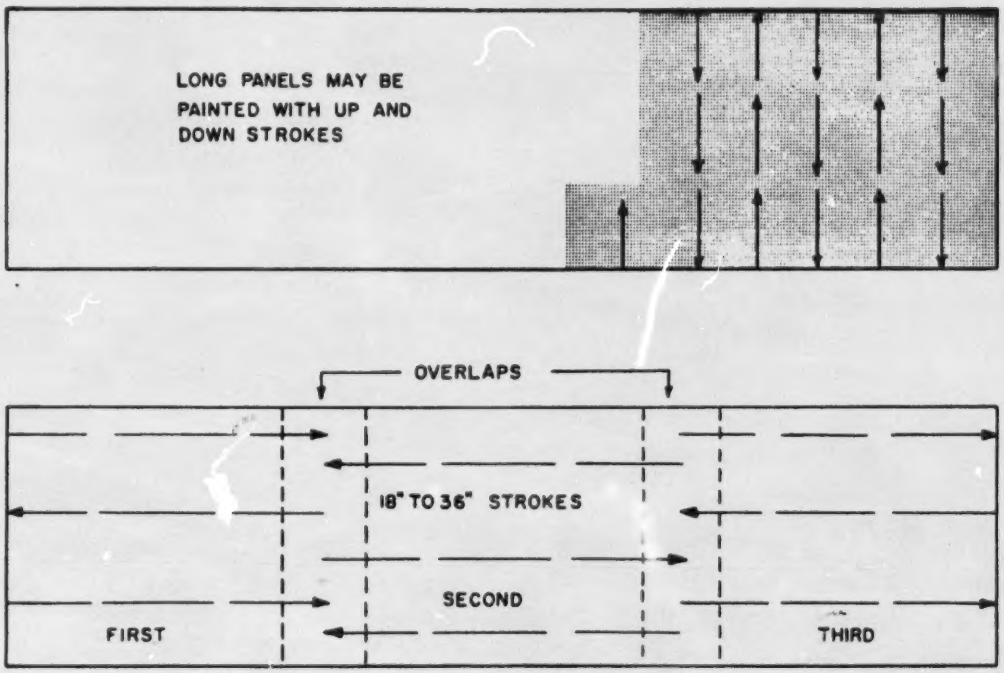

Figure 53. Spraying long panels.

16-23. Inside corners are more difficult to spray, since more strokes are required. When spraying an inside corner, each face of the corner is sprayed separately, as shown in figure 55. First, a vertical stroke is made at the corner from the top down. Then, horizontal strokes are used to spray the area next to the corner.

16-24. Films applied by air-atomized spray will tend to be somewhat thinner than those applied by brush. In some cases the sprayed coating gives good protection with a dry film thickness of only approximately 1 mil ($\frac{1}{1000}$ inch) per coat.

16-25. *Airless spray.* Airless spray application is somewhat similar to spraying water through a garden hose. The paint is atomized by the force of hydrostatic pressure through a nozzle. The type and size of the surface to be coated determines which one of an assortment of nozzles to use. Spray tips are available to produce pattern widths that range from 15° to 95°.

16-26. Hydrostatic pressure combined with the size of the spray tip orifice determines the amount of material that will pass through the nozzle in a given period of time (flow rate).

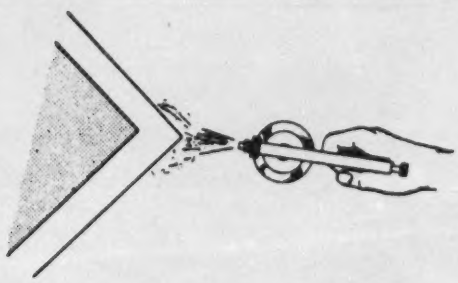

Figure 54. Spraying outside corners.

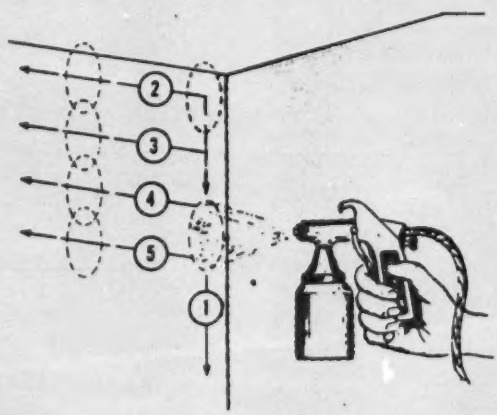

Figure 55. Spraying inside corners.

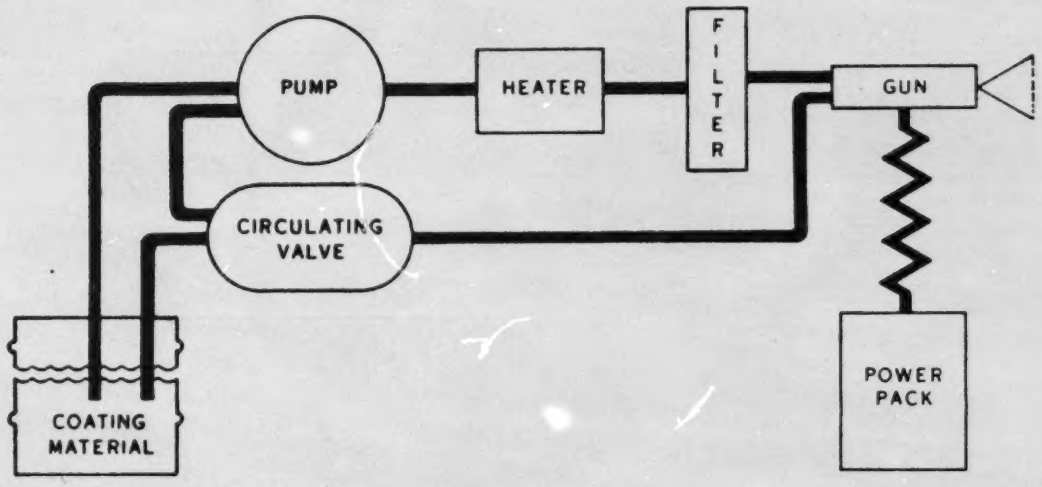

Figure 56. Electrostatic paint system.

This rate will vary according to the type and viscosity of the coating and the size of the nozzle orifice. Heavy-bodied coarse materials need larger spray orifices than do materials for finely ground finish coats.

16-27. The handling techniques of the airless spray gun differ from those of the air-atomized gun in that the airless spray gun is held from 12 to 16 inches from the surface being coated and is moved at a more rapid rate. This action is necessary because of the heavier material.

16-28. Some of the basic advantages of airless spray over the air-atomized spray method are as follows:

- Greater reduction in over spraying.
- Application of heavier films is possible.
- Materials may be applied without thinning.
- Rate of production is considerably faster.
- Consumption of air is substantially lower.

16-29. *Electrostatic spray unit.* The electrostatic unit is basically an electronic, air-operated system. This system adds an electrostatic charge to the coating material droplets. An electric powerpack provides extremely high voltage at low amperage to create a magnetic force between the work piece and the spray particles. The soft forward velocity of the paint and the electrostatic attraction principle help guide the individual coating particles to the workpiece and aid both penetration and wraparound of the protective coating. Nonmetallic products may also be coated after an initial preparation with a conductive material. Figure 56 illustrates the basic system. The air-operated portion of the electrostatic unit consists of a circulating valve, pump, heater, filter, and electrostatic hand gun.

16-30. The first requirement for safe electrostatic painting, because of the nature of its operation, is that the hand gun must be safe. The gun should not be capable of giving an objectionable shock to the operator or of producing an electric spark, even under the most adverse conditions. Secondly, all conductive objects in the spray area must be positively grounded. This includes the spray booth, racks, workholders, the article being painted, all solvent cans, the floor, and even you, as the operator. You should wear conductive shoes. Wear shoes with ordinary leather soles, but *do not* wear rubber or cork soles. If you wear gloves, you must cut the palm out of the gloves to allow contact of your hand with the gun handle.

16-31. Some of the advantages of electrostatic painting are the saving of paint, improved operator health and working conditions, and faster painting with better quality. Because more of the paint is deposited on the article being painted, less overspray is wasted on walls, floor, and on the operator. Face masks and protective clothing can often be eliminated and less elaborate paint booths and exhaust systems can be used. Since the paint particles are drawn to the article being painted, improved quality with less operator effort often results. For example, a cylinder or pipe can be painted from the front side as the magnetic attraction will cause the paint to wrap completely around it. As the paint covers one area, it will insulate that area and cause the paint particles to seek out and cover bare areas.

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16-32. The air-atomized spray and the airless spray, as well as brushing and roller coating of metal surfaces, are used extensively in the field. The flow or dip method of painting, as well as the use of the electrostatic spray unit, are pretty well limited to the paint shop area.

16-33. You have learned about the methods used in the application of protective coatings to metal surfaces. Now, let's discuss some of the peculiarities involved in painting certain types of metal surfaces.

16-34. **Painting Structural Steel.** New structural steel for service at atmospheric exposure is generally cleaned and shop-primed soon after its rolling or fabrication at the mill and prior to shipment to the construction site. Areas on the steel which are damaged during erection and all abraded or corroded spots on such shop-coated surfaces should be wire-brushed and spot-primed with material similar to the shop coat.

16-35. New steel, which has no shop coat, can be cleaned by wire brushing. Experience has shown that removal of all scale, rust, and other foreign matter is generally unnecessary to obtain an adequate paint job for normal exposure. This is true provided you use primers which contain a large portion of free linseed oil. Such oil type primers have the ability to effectively wet the surface and penetrate to base metal beneath the edges of mill scale and tightly adherent rust.

16-36. Structural steel surfaces, which are subject to water immersion and abrasion, should be sandblasted to the base metal to obtain satisfactory results. Immediately after blasting, the surface should be pretreated, prior to priming or painting. Either the chemical metal conditioner or the vinyl wash coat method may be used.

16-37. **Painting Galvanized Surfaces.** Galvannized surfaces are generally left unpainted at least during their early life, since the purpose of galvanizing itself is protection of the base metal. However, for the sake of appearance or additional protection, painting is rather frequently done. In any event, painting should be initiated at the first signs that the galvanizing is not adequately protecting the underlying base metal. The greatest problem in connection with painting of new galvanized surfaces is in obtaining and maintaining good adhesion, since most paints do not adhere well to this type of surface. However, the vinyl-type wash coat adheres well if oil, grease, and other contaminants are first removed from the galvanized surface by washing with solvents and wiping dry. For use over the vinyl wash coat, zinc dust paint may be used. Zinc dust pigmented paint is suggested since it performs quite well on galvanized surfaces, even without the vinyl wash coat. However, once adhesion to the galvanizing is established by means of the vinyl wash coat, almost any type or color of paint suitable for the exposure conditions may be used in place of the zinc dust paint with good results. For example, in interior exposure, painting of galvanizing would normally be done only for appearance and in such cases the vinyl wash coat might well be followed by whatever paint is being used on adjacent surfaces.

16-38. **Painting Aluminum Surfaces.** Aluminum surfaces will normally be left unpainted. However, where such surfaces are to be exposed for prolonged periods to moisture, concentrated chemical fumes or industrial gases, painting is generally advisable. Gutters subject to collection of debris, flashing in contact with concrete, contacting surfaces with other metals and contacting surfaces with damp wood are also situations in which the protection of aluminum is indicated. The surfaces should be cleaned with solvents to remove heavy grease and oil accumulations and then treated with the vinyl-type wash coat.

16-39. There are other satisfactory methods of preparing aluminum surfaces, such as anodizing, hot dip phosphate treatment, and hot dip chromic acid treatments but they are for the most part not adaptable to field use.

16-40. The paint system recommended for exterior aluminum surfaces consists of the vinyl wash coat, two coats of a phenolic-type zinc chromate aluminum primer followed by a phenolic-type aluminum finish coat. One of the two coats of primer may be omitted, if desired, where the exposure conditions are not severe. In the absence of the paints for the suggested system, any high-quality primer, the pigment content of which consists of 50 percent or more of zinc chromate, may be used either over bare metal or over the vinyl wash coat. Follow by one or more finish coats by high-quality aluminum paint or other finish color as required. In general, paints containing lead pigments should not be used for the first coat on aluminum surfaces. Exterior lead-free house paints may be used in painting aluminum siding subject to normal exterior exposure with good results. High-quality bituminous paints may be used to advantage in painting aluminum flashing which is in contact with concrete or mortar and in painting the inside of gutters. Aluminum surfaces in contact with dissimilar metals should be cleaned and protected, as was explained in paragraph 14-9.

16-41. **Coating Metal Tanks and Piping.** The proper painting of metal tanks and piping is dependent on the type of metals used, the type of materials to be stored, and their size and physical location. Tanks may be located overhead, at ground level, or underground. They may be lo-

cated outside, or they may be located inside structures, such as mechanical rooms, or powerhouses. You may find piping in ceilings, walls, floors, or underground. Your job, as a protective coating specialist is not to repair leaks or replace piping. Your responsibility is preventive maintenance and you should make surface repairs and apply protective coatings which will extend the useful life of these items.

16-42. *Overhead piping.* Overhead piping is generally coated for appearance. In some cases, it must be painted or color-coded for identification. If you find evidence of corrosion damage, usually at fittings or on threaded surfaces, you should clean the area with a wire brush. Apply a coat of red lead primer and then finish with the desired color of finish paint.

16-43. *Underground piping.* Protective coating on underground piping will provide a little more challenge to repair. You will become aware of the necessity for this work only when corrosion has advanced to the stage of causing a leak. When this happens, you will receive a work order to provide a protective coating to the repaired area after the leak has been repaired and before the pipe is covered up. In most cases, the underground pipe will have been coated when new with a coal-tar primer, wrapped with bonded asbestos felt or kraft paper, and finished off with a thin coat of coal-tar enamel. To properly clean this type of surface for repairing, use a scraper, wire brush, flame torch, and possibly an organic solvent. After you have cleaned the area—it may be a patch or a section of new pipe—rebuild the protective coating, overlapping the edges of the original coating. Be extremely careful to prevent earth or rock from adhering to any portion of the repaired area, and be sure that no holidays are left in the wrappings. The completed repair should completely seal the pipe so that it will resist any moisture. Coal-tar enamel protects steel pipe for long periods of time. Service records indicate a service life of 50 years or more.

16-44. *Copper pipe.* Copper pipe or tubing is being used extensively in building water supply systems. Copper pipe, 3 inches or larger in diameter, may be used for sanitary drainage systems. Portions of this piping may be in exposed locations in buildings, and you may paint it for appearance. Copper surfaces to be painted should be solvent-cleaned and treated with vinyl-type wash coat. When cleaning around soldered fittings, you should remove all wax or residue left by the solder flux. Any green-colored film, which is a sign of corrosion on copper, should be removed with steel wool. The vinyl wash coat treatment is recommended, although you may have some success in applying interior semigloss oil-base enamel directly to the copper. This is true provided the surface has aged sufficiently to produce a thin oxidation coating, and there are no grease, corrosion, or highly polished areas present.

16-45. *Underground tanks.* Underground tanks are used for storage of inflamable liquids, such as diesel oil and gasoline. Such tankage is left unpainted on the inside surface but you must provide a protective coating to the exterior surfaces. New tanks are generally received with a shop coat primer already applied. You should wire-brush any damaged spots and touch up with a similar primer. You can then brush or swab on a coating of bituminous compound, or spray on one or two coats of coal-tar enamel, before the tank is lowered into the excavation. After the tank is set and all pipe connections have been made, you should touch up and repair any damage to the protective coating which may have been caused by the hoisting equipment.

16-46. *Overhead tanks.* When we speak of overhead tanks, most of us immediately think of water towers used for storage of potable water. The painting of such tanks is generally done by contract; however, you may do maintenance painting or possibly complete painting of these tanks at remote or oversea locations.

16-47. The hazards involved in painting overhead tanks are great. Not only will you be working at great heights with the possibility of falling, but there is also the danger of asphyxiation from dust while sandblasting or from fumes when painting tank interiors.

16-48. A four-coat paint system is recommended for the interior of potable water tanks. The system requires that you sandblast the tank interior to a white-blast condition and immediately treat the surface with either a vinyl wash coat, or a chemical metal conditioner. You then apply four coats of zinc dust-zinc oxide, phenolic-type paint. The zinc dust for this paint is packaged separately and must be mixed with the base paint immediately prior to use. The natural color of the paint is light grey. The paint dries to a very hard film and the drying time between coats should be no longer than is required to produce a semihard film, in order to avoid poor intercoat adhesion. In very warm weather, 4 to 6 hours of drying time between coats should be sufficient. If more than a 24-hour drying period elapses in warm weather, the succeeding coat may be thinned with ethylene glycol monobutyl ether to improve intercoat adhesion.

16-49. The size of, and the physical location of, water towers and other overhead or ground-level storage tanks, determines the color scheme for painting the exterior of the tanks. Many of

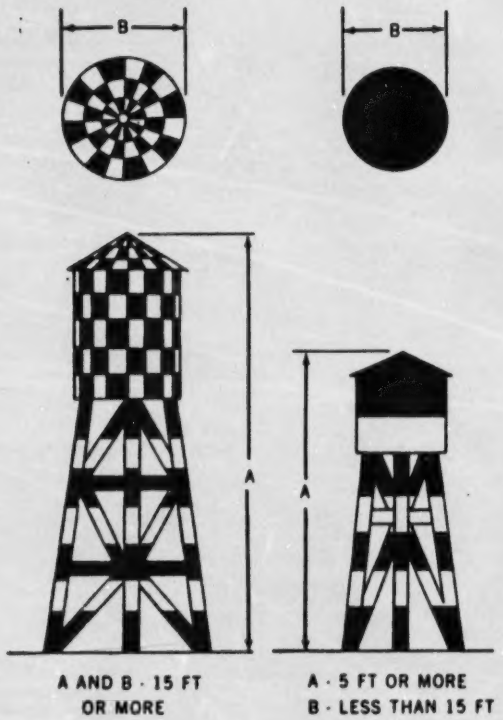

Figure 57. Marking water towers and similar obstructions.

these tanks, due to their location in relationship to the airport reference point, will be classified as obstructions to air navigation. All such structures must be painted with obstruction markings as set up by the Air Coordinating Committee. *The National Standard of Obstruction Marking*, published by the committee, is included as an attachment to TM 5-330, and you should consult the regulation which is current at the time you do any painting.

16-50. Obstructions shall be marked by the use of surface colors. Objects shall be painted aviation surface orange or a combination of aviation surface orange and aviation surface white. A summary of the color requirements is set forth below.

a. Solid. An object, the projection of which on any vertical plane has both dimensions less than 5 feet, shall be colored aviation surface orange.

b. Bands. An object with essentially unbroken surfaces, the projection of which on any vertical plane is 5 feet or more in one dimension and is less than 15 feet in the other dimension, and any skeleton or smokestack type of object having both dimensions 5 feet or more shall be colored to show alternate bands of aviation surface orange and white. The widths of the orange and white bands shall be equal and the width of each band shall be approximately one-seventh the length of the major axis of the object, provided that each band shall have a width of not more than 40 feet nor less than 1½ feet. The bands shall be perpendicular to the major axis of the obstruction. The bands at the extremities of the object shall be orange. Figures 57, 58, and 59 illustrate the application of this requirement.

c. Checkerboard Pattern. Objects with essentially unbroken surfaces, the projection of which on any vertical plane is 15 feet or more in both dimensions, shall be colored to show a checkerboard pattern of alternate rectangles of aviation surface orange and white. The rectangles shall be not less than 5 feet and not more than 20 feet on a side, the corner rectangles being orange. Figures 57 and 58 illustrate the application of this requirement.

d. Marking Spherical Shaped Obstructions. If a part, or all of certain objects of spherical shape does not permit the exact application of the checkerboard pattern of coloring, then the shape of the alternate rectangles of orange and white covering the spherical shape may be modified to fit the particular shape of the structural surface, provided the dimensions of the modified rectangles remain within the dimensional limits. Figure 59 illustrates the application of this requirement.

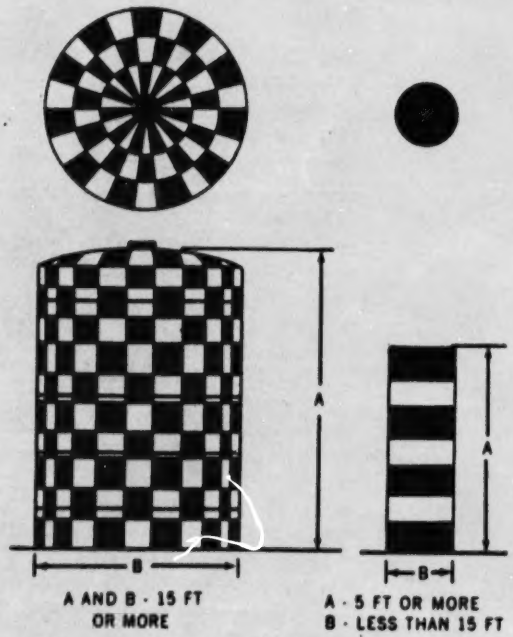

Figure 58. Marking gas holders and similar obstructions.

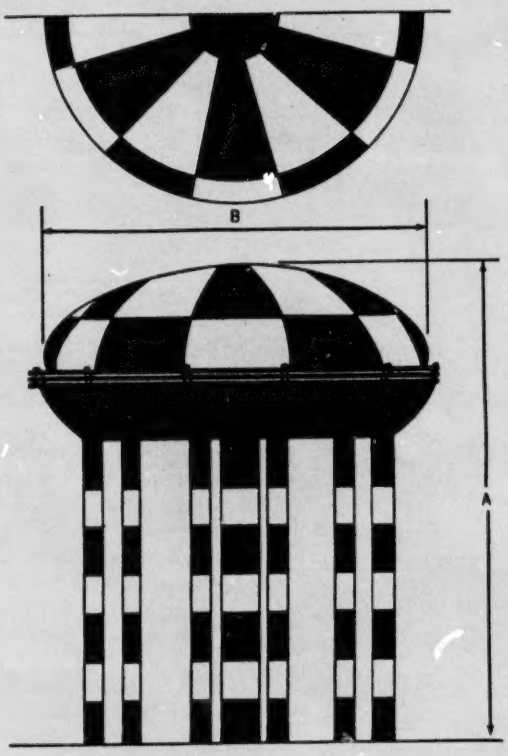

Figure 59. Marking spherical shaped obstructions.

16-51. Overhead or ground level tankage, which is not classified as being obstructive, will generally be painted aluminum or white. These colors are reflective in nature and tend to reduce heat buildup from direct rays of the sun.

16-52. Because of the costs involved, and the personal danger associated with painting overhead tanks, the best possible paint job should be accomplished. The most effective cleaning methods should be used along with top quality primers and paints to insure the longest possible life of the paint job.

16-53. Coating Machinery and Equipment. As a protective coating specialist, you will be required to paint various types of machinery and Government-furnished equipment located throughout Army buildings and structures. On fabricated and assembled items, such as motors, pumps, electrical equipment, and other mechanical equipment, paint systems conforming to the manufacturer's standard practice should be used in all practicable cases. You may find instances where there is a need for conformance to a uniform color scheme or where exceptional corrosion conditions must be combatted.

16-54. The initial cleaning of such equipment generally consists of the removal of grease, dirt, or other foreign materials. This cleaning may be done with a solvent rag, or it may include the use of chemicals, or mechanical cleaning equipment. Before you do any painting, you should observe the surface area in general. There may be gaskets, chrome, gages, lubricating fittings, instruction plates, and similar items which need to be protected. Masking tape, masking paper, and masking compounds are used for covering the areas which are to be protected.

16-55. *Masking tape.* You should cover small areas on irregularly shaped objects or parts with masking tape, since it stretches and conforms to surved surfaces. Large areas require a sheet of wrapping or any other type of paper slightly smaller than the part to be masked. The paper is held in place by a strip of masking tape.

16-56. *Masking paper.* Masking paper is a form of masking material that you can apply to smooth surfaces. It is a strong, lightweight paper coated on one side with an adhesive. You use it merely by applying a light pressure with your fingers and hand, and it requires no heating or moistening. You can easily remove masking paper without leaving any deposit of adhesive on the surface to which it was applied.

16-57. *Masking compounds.* There are several prepared liquid or pastes that will serve as masking compounds. You can apply these either with a brush or with a spray gun. The compound produces an excellent protective film. After the masking compound has served its purpose, you can wash it off without leaving any discoloration or spotting of the masked surface.

16-58. Another material you can use to mask surface areas is paraffin. Paraffin is very effective and water resistant and can be applied very easily. To mask an area with paraffin, you first outline it with masking tape. Melt the paraffin over a low flame until it becomes as liquid (approximately 150° F.), and then apply the melted paraffin over the surface by brushing. After the masking has served its purpose, you can peel it off in a manner similar to removing masking tape.

16-59. Spray application is standard in the painting of mechanical equipment. All safety precatuions regarding personnel health, fire prevention, ventilation, and electrical grounding are mandatory. You must always select and use the proper paint for the surface being painted. Hard-drying implement enamels or paints are suitable for application to most mechanical surfaces. Heat resistant paints should be used on surfaces which reach extremely high temperatures during

normal operation of the equipment. You should never paint machined surfaces that move with respect to each other, such as threads, bearing contacts, or gear teeth. Do not paint electrical parts, such as contacts, relays, insulators, sockets, plugs, connectors or terminals.

16-60. After painting machinery, equipment, pipes and tanks in shop areas or mechanical system rooms, you must apply stencils and markings. These markings are required for safety reasons and to aid the mechanic in performance of operator maintenance on the systems.

17. Application of Stencils and Markings

17-1. In the interest of uniformity, legibility, and neatness, freehand painted signs are not recommended for use in military structures. Regulations require that no smoking areas be marked with signs. Electrical outlets must be marked to indicate 110 volts, 220 volts, ac or dc, and piping systems must be marked to show the direction of flow as well as the contents of the pipe. Figure 60 shows a group of pipes which are marked. One pipe is marked "DOMESTIC HOT WATER," one is marked "COLD WATER," and one is marked "GAS." The arrow on the water line indicates the direction of flow of the water in the line. These markings were applied by using laminated marking decals. This type decal has an adhesive backing which makes it easy to apply to the surface. Decals, plus other types of laminated markings, are usually available for marking no smoking, restrooms, offices, and other common applications. These markings may be made of metal, wood, or plastic, and you can apply them by using adhesives, nails, or screws.

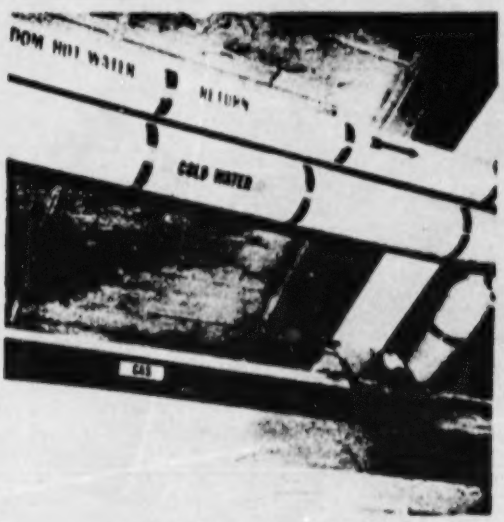

Figure 60. Pipe markings.

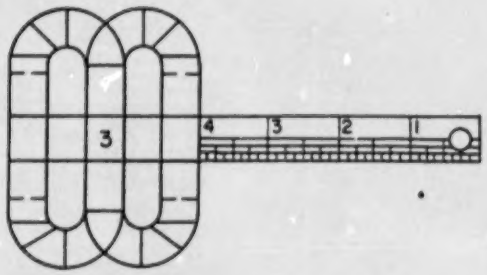

Figure 61. Stencil key set.

17-2. When laminated markings are not available, you can prepare a stencil for any desired sign. A stencil is simply a thin piece of cardboard in which the letters of a sign have been cut out. You use the stencil as a guide by placing it against the surface and painting through the cutouts in the board. When the paint has set sufficiently, remove the stencil and you have a neat, legible sign, remaining on the surface.

17-3. **Stencil board.** Stencil board comes in two grades, a high-wear resistance (grade 1) and a moderate-wear resistance (grade 2). The grade 1 board is available in sheet sizes 8″ x 24″, 20″ x 32″, and 24″ x 36″. The grade 2 board comes only in one sheet size, 20″ x 24″. You select the grade of stencil board by the number of times the stencil will be used.

17-4. **Stencil Key Set.** The stencil key set is used as a guide for layout and for drawing letters and numbers on stencil boards. A 3-inch stencil key set is shown in figure 61. To use the stencil key set, first mark off a horizontal line on the stencil board. Then use the key set to outline the desired numbers and letters, using either the inside or outside of the set. After all the letters have been outlined on the stencil board, simply cut them out with a sharp knife or razor blade.

17-5. **Stencil-Cutting Machines.** Stencil-cutting machines vary in appearance and size. Regardless of the size (from ¼- up to 4-inch cutters), the machine will have a handwheel to position an indicator to the letter, number, or mark to be cut, and a cutting handle to depress. The rotating handwheel portion of the stencil machine contains the punch, which is positioned under the cutter handle. Positioning the indicator brings the punch in alinement with a "die" in the lower portion of the machine. You depress the cutting handle which forces the "punch" into the "die," thus cutting the desired letter or number into the stencil board. To space a word, you rotate the handwheel to a blank spot, depress the handle, and as it is released, the board moves to the left and into position for your next word.

17-6. You can apply markings by using the stencil and a stencil brush, stencil roller, or by spraying. There are three types of stencil brushes:

a. Artist's stencil brush. This brush is round with black bristles in a long polished cedar handle. The bristles are held in place by a metal ferrule. The diameter at the ferrule is ½ inch and the bristle length is 1 inch.

b. Stencil brush. This brush is made of 100-percent hog bristles, with the flag ends cut. It has a long wooden handle and comes in either $1\frac{3}{16}$" x $1\frac{5}{16}$" or $1\frac{1}{16}$" x $1\frac{1}{16}$" sizes.

c. Fountain stencil brush. This is a brush with a reservoir handle. The leakproof reservoir holds a minimum of 2 ounces of stencil ink. The bristles extend 1½ inches beyond the metal ferrule. A shutoff is provided between the reservoir and the brush to adjust the flow of stencil ink as well as to shut it off completely.

17-7. **Stencil Ink.** While any suitable paint may be used for stenciling, there is a specific ink to be used with the above brushes. Stencil ink is an opaque ink that will mark porous surfaces, wood and cardboard shipping containers, burlap, and canvas. This ink comes in the following colors: black, white, and yellow. To use a brush, apply the ink with a "dabbing" motion, keeping the brush perpendicular to the surface. The stencil brush is never "stroked" in applying the ink. It is strictly a jabbing or tapping motion of the brush against the surface.

17-8. **Stencil roller.** You can use a stencil roller to spread paint. This roller is 2 inches wide and 1½ inches in diameter. Roll the stencil roller over a small amount of paint spread on glass or a metal sheet; then roll it over the stencil on the sign. As soon as possible after the sign is stenciled, cut in the ties (space in letters or numbers) with a small, flat brush. This is important because the brush work will not blend with the rolled work and ties will show if the paint is permitted to dry before the ties are filled in.

17-9. **Pressurized spray cans.** The pressurized spray can may be used for painting small signs. These spray cans are easy to use and come in various colors. The only requirement before using them is that they must be shaken until the ball inside the can rolls freely. Shake the spray can to thoroughly mix the paint, hold the can 6"–8" from, and horizontal to, the surface of the stencil and depress the button. Now move the can horizontal to the spraying surface until you have an even coat of paint. Allow the paint to dry before removing the stencil.

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CHAPTER 4

Inspection of Surfaces

WE KNOW THAT the proper application of a correct protective coating will enhance the appearance and prolong the life of any structure. We also know that paints have the ability to cover many mistakes and produce false impressions to a casual observer. It is necessary then that the inspector not be a casual observer in his inspection duties but rather a close observer of materials, workmanship, safety, and finished surfaces to assure a quality product.

2. As you progress up the protective coating career ladder, by obtaining more technical knowledge and becoming more proficient in your job, you may have the opportunity to work as an inspector. There are several types, or degrees, of inspection which you may perform.

3. You may be assigned by your supervisor to inspect a structure or a group of buildings to determine the condition of their protective coatings. In this case, you may be required to inspect the condition of the protective coating, determine the cause of any coating failure, and calculate the square footage of the surfaces. You can then determine the type and amount of materials required to apply a new protective coating.

4. Again, you may be assigned by your supervisor to represent him, or to inspect the quality of workmanship of other protective coating specialists. In this case, call on your past experience and technical knowledge, to insure that the job is done properly. There will be no specifications for the job, and you must make your decisions based on standard practice. Inspect the surface preparation, the methods used during application, proper film thickness, and overall quality of the work. You should make recommendations, based on the inspection, to your supervisor as the work progresses.

5. Still another type of inspection to which you may be assigned is contract inspection. In this case, you would be either detailed or assigned to work as an inspector or field supervisor. Here, your decisions must be based on written specifications which are a part of the contract. The specifications and drawings, along with any written changes go together to form the contract between the Army and the contractor. From an inspector's point of view, you will have no right to allow any deviation from the specifications. The specifications are the only documents that you have available to arbitrate any dispute. You, as the inspector, are responsible to insure that the Army receives a full dollar's value for each dollar spent.

18. Inspection of Old Protective Coatings

18-1. Periodic inspection is an intergal part of any well-organized preventive maintenance program. You must periodically inspect the protective coating on buildings and structures to determine the condition of the old coating and to identify the cause of abnormal coating failure.

18-2. **Condition of Old Coating.** Chapter 1 of this Memorandum gave the stages through which the normal deterioration of paint progresses. You also learned the causes, or conditions, which lead to abnormal deterioration of protective coatings. All the stages of deterioration are applicable to painted wood, masonry, or metal surfaces. Only a few of these conditions will justify the expense of complete removal of the old coating. You must decide each case based on its own merits. You must consider the price that can be paid for first-class appearance, the frequency of repainting that might be necessary without the removal of the old coating, and the estimated future life of the building.

18-3. **Causes of Coating Failure.** It is a well-known fact that the early failure of a protective coating is generally the result of poor surface preparation. This is especially true on masonry or metal surfaces which show early signs of scaling and flaking. Equally conspicuous scaling on wood surfaces may be caused by heavy bands of summerwood in the wood grain or by the entrance of water into sidewalls. You must be able to recognize the cause of the coating failure

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on any surface and make recommendations to prevent future occurances.

18-4. *Wood surfaces.* The protective coating on exterior wood surfaces should deteriorate normally by the chalking process. The coating should have a life expectance of 4 years under average exposure conditions. Paints that do not deteriorate by checking or cracking will waste away by chalking, until they become too thin to hide the wood. This will continue until patches of the wood begin to be laid bare. The surface should be repainted when the coating becomes thin enough to show the grain of the wood or when patches of bare wood begin to appear.

18-5. When coatings develop into checking patterns, disintegration will occur by crumbling. When the coating develops cracking with curled edges, disintegration will be by flaking or scaling. Repainting should be done soon after the most exposed parts of the building have reached the stage of disintegration by flaking or scaling.

18-6. When paints deteriorate with undue rapidity or in an abnormal manner the condition responsible should be determined and corrected before further painting is done. Dense species of lumber, such as those of group 4 woods, should be replaced when practicable to reduce the possibility of checking and cracking. You should inspect surfaces for evidence of discolorations, such as blue stain, which indicates the presence of moisture in the wood. The source of moisture should be determined and recommendations made for eliminating or preventing it.

18-7. *Masonry surfaces.* Protective coatings on masonry surfaces will deteriorate by chalking unless conditions exist which cause flaking and scaling. When you find this condition, you should inspect the surface for signs of efflorescence, alkalinity, or glaze. After you determine the cause of the coating failure, you should make recommendations for treating the surface, prior to repainting.

18-8. *Metal surfaces.* Corrosion is the No. 1 enemy of metal surfaces, so when inspecting, always be alert for signs of it. Check all damaged areas in the protective coating for signs of rust or scaling. Check aluminum or galvanized surfaces for looseness or flaking of paint. Examine all fasteners, hangers, and brackets for corrosion which may be caused from dissimilar metals. Scrape off loose paint at blisters and scaling on surfaces and examine the base metal for corrosion.

18-9. **Measuring Corrosion Pitting.** Corrosion pits can be measured with a dial indicator. To use it for measuring the depth of corrosion pits, select a locally made steel bar adapter which is at least 4 inches in length to bridge any waves or bends in the surface being checked. The dial indicator is mounted in the center of the steel bar, as shown in figure 62.

18-10. Calibrate the dial indicator by positioning it in the bar so that the dial indicator

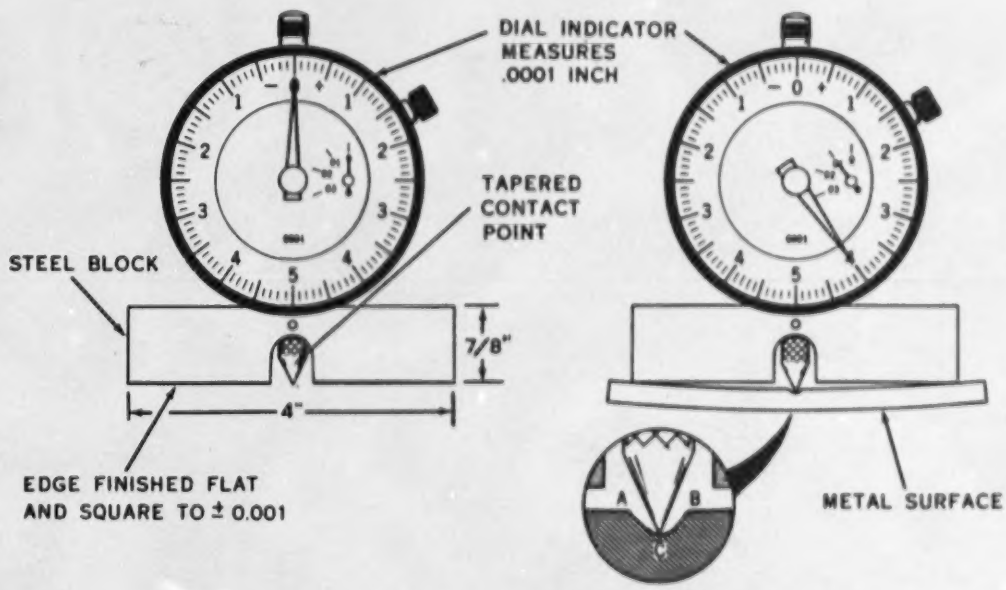

Figure 62. Dial indicator.

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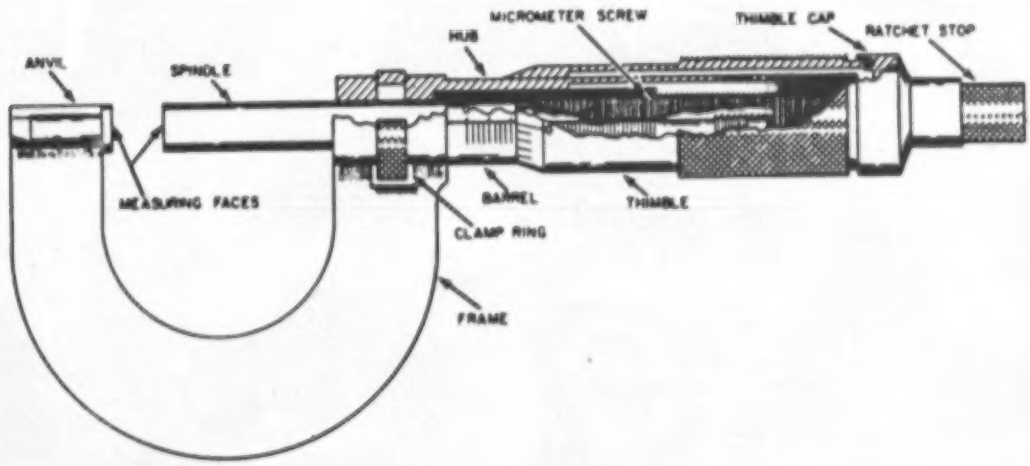

Figure 63. Micrometer.

pointer extends slightly below the bar. Then place the steel bar on a flat surface which will cause the pointer of the dial indicator to be depressed. Loosen the knurled knob on the side of the indicator and adjust (rotate) the face so that the instrument's needle is set to the zero position. The instrument is "zeroed in" at this setting and you secure it by tightening the knurled knob on the side of the indicator. As you lift the instrument and bar, the pointer should extend past the flat bar surface moving the needle away from the zero position.

18-11. You are now ready to measure the depth of corrosion pits with the dial indicator. You place the straight edge of the bar against the uncorroded area of the metal on one side of the corroded area. If the gage needle moves from the zero mark, record the amount (let's say the first reading is 1). You move the gage to the other side of the corroded area and take another reading—recording the amount (the second reading is also 1). Now, move the gage so that the gage pointer is resting in a pit in the corroded area. You move the gage until you find the deepest pit (shown by the highest reading on the gage), which is 6 on the needle dial. Now, let's take a look at our reading:

Reading # 1	0.001
Reading # 2	0.001

1 is the base number instead of 0 (These would be averaged if they were different)

Pit depth reading	0.006
Pit depth	6
Minus base reading	1
5 = actual total depth of corrosion pit	

18-12. So far, you have only measured the depth of the corrosion pits. You must now measure the original thickness of the structural material to determine the damage caused by the corrosion. If the thickness of the structural material is not known, you can measure the thickness with a micrometer.

18-13. **Micrometer.** The micrometer is the most accurate of the adjustable measuring instruments. The tool is capable of measuring to within 0.001 inch; on one equipped with a vernier scale, the measurements can be read to within 0.0001 inch. Figure 63 is a drawing of an outside micrometer. The screw has 40 threads per inch so that when the thimble is turned one complete revolution the end of the spindle is moved 0.025 inch ($\frac{1}{40}$ inch). The sleeve of the micrometer is marked off in 40 equal spaces so that the number of revolutions may be known. The end of the thimble is marked off in 25 equal spaces so that when the sleeve is turned through the distance between two of these marks, the spindle is moved 0.001 inch from, or toward the anvil. The outside micrometer illustrated is used to measure the outside diameter of shafts, the thickness of materials, and other similar dimensions.

18-14. The range of a micrometer is usually 1 inch. The size of a micrometer is the largest dimension it will measure. A micrometer that measures 2 to 3 inches is referred to as a 3-inch micrometer.

18-15. When using the micrometer, apply very slight tension. Turning the spindle clockwise will bring it closer to the anvil. You should place the material to be measured betwee- the

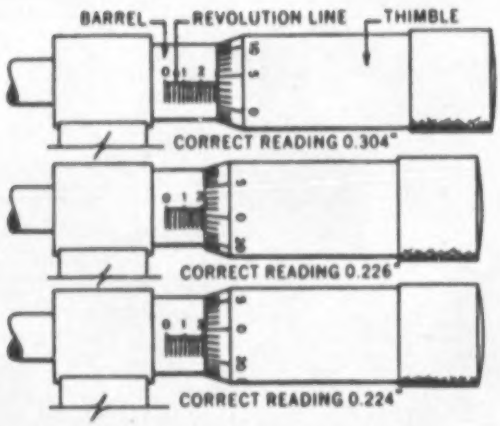

Figure 64. Micrometer reference lines and graduations.

anvil and the spindle and turn the spindle until the material is brought into contact with the anvil under a slip tension (a side movement or slipping of the micrometer across the surface being measured). Once contact is made, avoid springing the C-frame through excessive gaging pressure. Always hold the spindle of the micrometer perpendicular to the material being measured.

18-16. Reading a micrometer is quite simple when you understand the principle. In most instruments the screw has a pitch of 0.025 inch. A reference (revolution) line on the side of the barrel (see fig. 64) parallel to the screw axis is graduated over a length of 1 inch into 40 equal divisions. The thimble end will coincide with the 0 graduation at the left end of the barrel scale when the spindle to anvil distance is exactly zero or an exact number of inches, depending on the instrument's capacity. To read the barrel scale, note that each fourth graduation is numbered, starting at the left end with 0 through 9, with a second 0 at the right end of the graduated inch. The tapered thimble end is divided into 25 equal spaces with every fifth graduation numbered. These graduations are so arranged that when the end of the thimble is properly aligned with any 0.025-inch graduation the zero is exactly aligned with the barrel reference (revolution) line, as shown in figure 64. Since the micrometer is graduated in 0.001 inch steps, it is customary to read it to the nearest thousandth of an inch.

18-17. We now have a method of measuring the depth of corrosion pits and a method for measuring the thickness of structural material. Once we have both of these measurements we can determine the extent of the corrosion damage as follows:

Thickness of structural material	0.09375 ($\frac{3}{32}$")
Depth of corrosion pit	0.005
	0.08875

Since structural material may fail by corrosion perforation when the average penetration is only one-fifth of the thickness, we are within a safe condition.

18-18. After you have inspected the condition of the old coating on wood, masonry, or metal surfaces, and determined the cause of abnormal coating failures, you should prepare a written report of your findings and recommendations. Any time your report calls for repainting of a structure, you should include an estimate of the materials needed for the job. To estimate the amount of primer or paint required, you must figure the area of the building's surfaces in square feet.

18-19. **Calculating Surface Areas.** Let's assume you have inspected the building shown in figure 65 and have recommended that it be repainted. The first step will be to measure the outside walls of the building. Measuring one side, you find the length to be 40 feet and the height 10 feet. Now multiply the length by the height ($40 \times 10 = 400$ sq ft) for one side—a total of 800 square feet for both sides. Measuring one end of the building, you find it is 20 feet wide and 10 feet high up to the eave. ($20 \times 10 = 200$ sq ft).

18-20. The two ends have a combined total of 400 square feet, not counting the gable ends. Because the gable end is a triangle, its area is found by taking one-half of the product of the base (20 ft) and height (5 ft). The problem works out: $\frac{1}{2} \times (20 \text{ ft} \times 5 \text{ ft}) = 50$ square feet. Now multiply by 2 for a total of 100 square feet for both gable ends. Now you add 800 square feet for the sides, 400 square feet for the ends, and 100 square feet for the gable ends. This gives you a total of 1300 square feet of exterior wall surface.

18-21. Generally speaking, the outside casings and molding of doors and windows require as

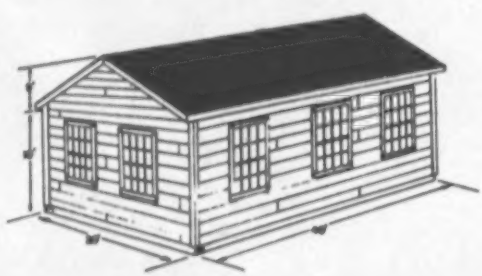

Figure 65. 20- × 40-foot building.

much paint as the same area of solid surface. Therefore, no deductions should be made for them, if they are to be painted the same color. It is quite difficult to make a statement as to the amount of surface a gallon of paint will cover. The covering capacity of paint will depend upon the following factors:

- Thickness of the paint.
- Method of application.
- Roughness of the surface.
- Absorption of the surface.

18-22. As a guide for you, figure 66 shows the approximate covering capacity of several paints for various surfaces. These estimates should be merely suggestions, since any or all of the previously mentioned factors alter the coverage capacities of the coatings.

18-23. If you have decided to use oil-base paint for the exterior walls, take a look at figure 66; notice that oil-base paint covers approximately 350 square feet per gallon. Now divide: 1300 square feet by 350 square feet = 3.7 gallons. So you figure 4 gallons to cover the exterior walls with one coat of paint. If two or three coats are to be used, you usually figure the same amount for each coat.

18-24. You should prepare a written report for each building. The report should contain such information as the condition of the old coating and the degree of surface preparations required. You should include the type of priming required, either spot or full prime. You should recommend either a one-, two-, or three-coat paint system and specify the type and amount of paint required.

Type of Coating	Type of Surface	Per Gallon	Per Pound	Coverage in Square Feet
Aluminum	Wood	1		600
Aluminum	Metal	1		700
Enamel Undercoat	Wood	1		300
Enamel	Plaster	1		500
Enamel	Concrete Floors	1		500
Enamel	Wood Floors	1		500
Epoxy	Concrete Floors	1		300
Glusize	Plaster			650
Lacquer	Metal	1		500
Paint, Oil	Wood Siding	1		350
Paint, Oil	Dry Wall	1		500
Paint, Oil	Metal	1		600
Paint, Oil	Plaster	1		500
Paint, Oil	Concrete	1		350
Paint, Oil	Brick	1		225
Paint, Oil	Stucco	1		150
Paint, Resin-Emulsion	Dry Wall	1		500
Paint, Rubber Base	Dry Wall	1		600
Paint, Water	Plaster			600
Shellac	Wood	1		400
Stain, Oil	Wood	1		300
Varnish	Wood	1		200

Figure 66. Paint coverage.

19. Inspection of New Protective Coatings

19-1. The inspection of new protective coatings is a full-time job. You must be on the job from the time the surface preparation begins until the painting is completed. You must insure that each step of the painting operation is done by using the proper tools and materials, and that all safety practices are observed at all times.

19-2. **Inspection During Surface Preparation.** Wood surfaces to be painted shall be cleaned of dirt, oil, and other foreign substances with mineral spirits, scrapers, or sandpaper. Glazing rabbets in exterior sash and doors shall be primed prior to glazing. Edges of doors that have been trimmed during hanging and fitting shall immediately be given two coats of primer. Small, dry, seasoned knots should be surface-scraped and thoroughly cleaned, and should be given a thin coat of knot sealer before application of the priming coat. Pitch on large, open, unseasoned knots and all other pitch shall be scraped off, or if still soft, shall be removed with mineral spirits. The resinous area is then coated with knot sealer. The surface must be checked to insure that finishing nails have been properly set. Then all holes and surface imperfections shall be primed. After priming, all holes and imperfections in finish surfaces shall be filled with putty, allowed to dry, and sandpapered smooth. You should allow painting to proceed only when the moisture content of the wood does not exceed 12 percent as measured by a moisture meter.

19-3. Concrete and masonry surfaces that are to be painted must be prepared by removing efflorescence, chalk, dust, dirt, oil, grease, excessive mortar, mortar droppings, and by roughening to remove glaze. Immediately before coating with cement-sand or cement-water paint, surfaces to be painted should be uniformly and thoroughly dampened. Sufficient time shall be allowed for the water to be absorbed, with no free surface water visible. Glazed surfaces shall be etched with acid-water, thoroughly rinsed with water, and allowed to dry.

19-4. Ferrous surfaces that have not been shop-coated should be solvent cleaned to remove oil and grease. Surfaces that contain loose rust, loose mill scale, and other foreign substances should be mechanically cleaned by power wire brushing, or sandblasting. Minor amounts of residual rust that cannot be removed except by thorough blast-cleaning and tight mill scale that cannot be removed by applying a sharp knife to any edge, may be allowed to remain. After cleaning, one coat of ferrous metal primer should be applied to the surface. The semitransparent film applied to some pipes and tubing at the mill is not to be considered as a shop coat, but shall be overcoated with ferrous metal primer. Abraded or corroded spots on shop-coated surfaces should be wire-brushed and touched up with material similar to the shop coat.

19-5. Galvanized surfaces to be painted shall be solvent-cleaned and treated with vinyl-type wash coat. Galvanized surfaces not to be painted shall be solvent-cleaned and inspected for condition of the galvanize coating.

19-6. Aluminum surfaces to be painted shall be solvent-cleaned to remove oil and grease and then be treated with vinyl-type wash coat. Surfaces not to be painted shall be solvent-cleaned. Prior to priming, all surfaces should be inspected for contact with dissimilar metals.

19-7. **Inspection During Coating Application.** Surfaces that have been cleaned, pretreated, or otherwise prepared for painting shall be given a coat of first-coat material as soon as practicable after such preparation has been completed, but in any event, prior to deterioration of the prepared surface. At time of application, paint should show no signs of hard settling, excessive skinning, or other deterioration. Emulsion paints shall be protected from cold weather by storing in protected shelters to prevent freezing of the paint.

19-8. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Paints of different manufacturers should not be mixed together. Where necessary to suit conditions of surface, temperature, and method of application, paint may be thinned in accordance with the manufacture's directions, but not in excess of 1 pint of thinner per gallon of paint.

19-9. Paints other than water-thinned coatings must be applied only to surfaces that are completely free of surface moisture, as determined by sight or touch. Do not apply paint to surfaces when there is visible frost or ice. While painting is being done, the temperature of the surfaces and of the atmosphere in contact with the surfaces, shall be at or above 50° F. for water-thinned coatings, and 45° F. for other coatings.

19-10. Sufficient time shall elapse between successive coats to permit proper drying. This period shall be modified as necessary to suit adverse weather conditions. Oil-base or solvent-type paints shall be considered dry for recoating when the paint feels firm and does not deform or feel sticky under moderate pressure of the thumb.

19-11. The finished surfaces must be free from runs, drops, ridges, waves, laps, and brush marks. There shall be no variation in color, texture, and finish. The hiding should be complete, and each coat should be so applied as to produce

a film of uniform thickness. Give special attention to insure that all surfaces including edges, corners, crevices, welds, and rivets receive a film thickness equivalent to that of adjacent painted surfaces.

19-12. **Determining Coating Thickness.** The process of paint changing from a wet-film to the protective dry-film layer is called the mechanics of coatings. This process may be a physical or a chemical change and should be grouped under solvent evaporation or oxidation. For the purpose of measuring the thickness of a protective coating, you must remember the drying characteristics of that coating. This is necessary because coating thickness can be taken by a dry- or wet-film gage.

19-13. *Dry-film thickness gage.* The dry-film thickness of paint on ferrous metal can be measured directly by the dry-film thickness gage shown in figure 67. The gage can measure the thickness of a nonmagnetic coating that has been applied to a magnetic base metal.

19-14. The dry-film thickness gage is more accurate on smooth surfaces than rough and is more accurate at ranges above 1 mil (0.001 inch) than below. The accuracy of the dry-film gage is plus or minus 10 percent provided the instrument is properly calibrated and used according to instructions.

19-15. The dry-film thickness gage is available in a variety of thickness ranges. It is lightweight, easy to use in hard-to-reach areas, and needs no source of electricity. The gage does not injure the coating in any way, and its reliability is accepted by contractors. The 0–20-mil instrument is best suited for checking most protective coatings. Before using the gage, calibrate it as follows:

- Clean a small area (size of gage) of the base metal.
- Set a nonmagnetic shim (of a known thickness) on the bare ferrous metal base.
- Position the gage over the nonmagnetic shim.

The dial reading should show the thickness of the nonmagnetic shim. If the dial reading is different than the known thickness of the shim, adjust the instrument until it reads the correct thickness. On a smooth, machined surface, the instrument should also read zero with the gage in direct contact with the surface. Even with coating thicknesses of several mils, the instrument may not read accurately if the base metal is roughened by blast coating. However, if the instrument is calibrated on the blasted or rough surface of the same base metal, the results should

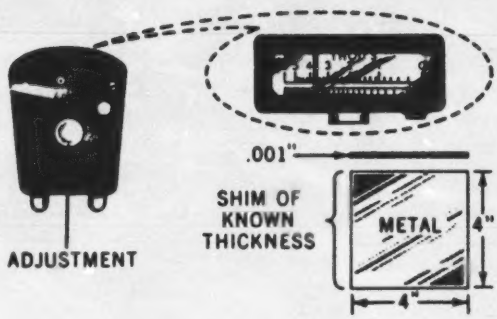

Figure 67. Dry-film thickness gage.

be reasonably accurate. You should recognize that on rough surfaces the thickness of the protective coating films varies between the peaks and the valleys. If you calibrate the instrument on a blast-cleaned surface, the test measurements you take on the same surface will generally be the thickness of the protective coating *above the average high* points of the blast pattern. The actual thickness of the coating over some of the highest peaks may be much less than the measurement shown on the instrument dial. To operate the dry-film thickness gage, place the sensing "feet" on the coating, press the release button, and read the thickness on the dial at the top of the instrument.

19-16. When measuring thickness, you should hold the sensing element of the gage lightly against the coating in order to avoid indentation. If the coating is indented, the gage readings will be lower than actual. The dry-film thickness gage should not be used to check the thickness of coatings nearer than ½ inch from an edge, on sharp interior angles, or on rough, pitted, or welded surfaces. You should make enough measurements to determine the general uniformity of the thickness of the coating. Since a measurement takes only a brief interval once the instrument is calibrated, there is no reason why hundreds of measurements on a single area cannot be made. By making numerous measurements, you can accurately determine if the minimum and maximum thicknesses prescribed have been complied with.

19-17. *Wet-film thickness gage.* Another means of determining protective coating film thickness is by use of the wet-film thickness roller gage illustrated in figure 68. This instrument measures the thickness of the freshly applied film. From the reading taken with this gage, the amount of paint per square foot of surface area can be figured. The wet-film thickness gage is available in the ranges of 0 to 4, 2 to 12, and 10

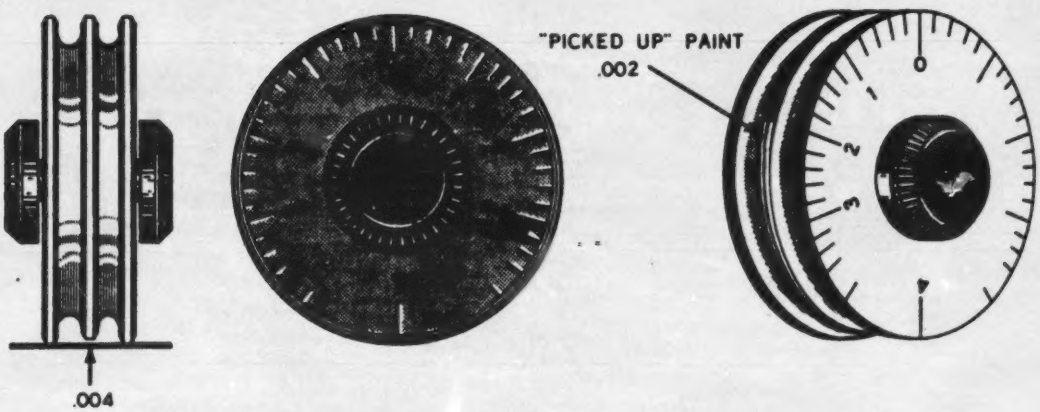

Figure 68. Wet-film thickness gage.

to 30 mils. The gage is an eccentric center wheel supported by two concentric wheels. The gage is held between the thumb and forefinger and is rolled across a freshly painted surface in the following manner. You place it against a plane surface. If you are using the 0- to 4-mil gage, the clearance between the inner eccentric wheel and the surface upon which the two outer concentric wheels rest ranges from 0 to 4 mils. Place the gage with the highest reading against the paint film and then roll it through about 180°. Obtain the reading by observing where the paint film was first contacted and "picked up" on the center eccentric wheel. Read the thickness of the paint film from either side of the two concentric wheels—at the point where the paint was first "picked up."

19-18. You can obtain an accurate reading with the wet-film thickness gage on any uniform surface hard enough to resist identation by the two outside wheels of the gage. If the gage is pressed too hard against a soft wood base or against a previously applied paint film which has not dried hard enough, you will not obtain an accurate reading. The gage is ideal for measuring the thickness of first coats on metal surfaces, but it has a doubtful accuracy when you measure the wet-film thickness on very quick-drying paints, such as vinyl resin primer, especially in warm weather when the fast evaporation of highly volatile solvents causes a very rapid decrease in the thickness of the paint film. Use great care in measuring the wet-film thickness of second coats of paint, especially if the first coats have dried only the normal time necessary to permit recoating. You can judge whether the wet-film gage will cause identation by rolling the gage over a portion of the surface to be painted.

19-19. *Dry-film test panel.* If paint film thickness measuring instruments are not available, use small aluminum panels for the measurement of the paint thickness after drying. You should apply a sufficient number of panels to the surface to be painted to get an average test of the film thickness. Prepare each panel by masking it with tape for a distance of approximately 2 inches. You attach the panels to the surface to be painted by the use of a small section of masking tape doubled upon itself, with the adhesive side contacting the panel and the surface to be painted.

19-20. The test panels should be removed from the surface after the paint is applied. The areas left unpainted under the panel should be touched up immediately. After the paint on the test panel has dried, its thickness is measured with an ordinary micrometer having flat contact surfaces. The protective tape is removed from the test panel and this surface is used as the base measurement. At least six readings should be taken on both painted and unpainted portions of each panel to provide an average paint thickness measurement.

19-21. **Cleanup.** Cloths and cotton waste that might constitute a fire hazard shall be placed in closed metal containers, or be destroyed at the end of each day. Upon completion of the work, all scaffolding, empty containers, and other debris shall be removed from the site. Paint spots or stains on adjacent surfaces must be removed and the entire job left clean and acceptable.

20. Contract Inspection

20-1. Should you be assigned as a painting inspector, the chief inspector will brief you on your new duties. In all probability, you will go through a period of transition during which you will receive extensive on-the-job training so

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that you learn to work with specifications as they apply to contract inspection.

20-2. **Specifications.** A specification is a written directive. It gives to you a word picture. The specifications are intended to provide a common basis of understanding by all concerned. They represent a clear and accurate description of the technical requirements for a material, process, product, or service, including the procedure by which one can determine that the requirements are met. A qualified engineer prepares a set of specifications for each construction project. The inspector must be able to interpret the specifications and determine when the contractor complies or does not comply with them.

20-3. A conference is held before the contractor starts the project. The inspector assigned to the project will sit in on this conference. The contractor will be advised by the contracting officer, as the conference goes through the provisions of the contract, that any change in the drawings or the specifications will be coordinated through the inspector and the inspection section and passed on to him. The contracting officer will make the decision, and the contractor will be informed, through the inspector, in writing.

20-4. After the contract is let and the construction begins, specifications serve as a checklist to the inspector to insure quality of material and workmanship. To accomplish this, the specifications will specify the following:

a. Quality and sometimes the quantity of materials used in construction usually referring to Federal specification numbers, grade, and condition.

b. Procedures for material acceptance.

c. Performance of the contractor during construction in:

- Material conservation.
- Procedure of installation of equipment.
- Tests that installed equipment must pass for acceptance.

d. Specifications are usually made up in sections. Each section will be listed in the index.

- Section 1, Painting.
- Section 2, Plumbing.
- Section 3, Electrical, etc.

e. Each section will list the requirements for that phase of the work. Typical requirements for paint are listed below.

- Type of paint by specification number.
- Cleaning and preparation of the surface.
- Storage and mixing of the paints.
- Methods of application.
- Number of coats or thickness.
- Safety requirements.

20-5. Only by looking at the specifications can you, as the inspector, know what is to be constructed. The specifications are the documents that explain what the contractor has contracted to do. It informs you as to just what the contractor is getting paid for. Since the contractor cannot be required to deliver any more than what is called for in the specifications, you must require compliance to what is in the specifications.

20-6. Since all construction must comply with the specifications unless otherwise authorized by the contracting officer, (this being authorized by a change order), you must make these change orders a part of the specifications and keep an up-to-date set of specifications in your possession at all times and make sure that the contractor also has an up-to-date set. When you first get a set of the specifications, read over them; and whenever you come to something that might cause differences that are of extreme importance or that are special items, mark them with a red pencil. This makes them easy to refer to and will help you to assure that these matters will be taken care of in due process of the construction. Thus they are less likely to be overlooked.

20-7. **Resolving Differences.** There will always be differences of interpreation that arise. The specifications are the only guide that the inspector has to go by. Any misinterpretation can change the entire concept. Therefore, any misinterpretation will be discussed at the preconstruction conference or when the misinterpretation arises. It may be necessary to discuss these items with the engineer. Since missing one word in the study of the specifications can change the entire concept, you may need to check the drawings for a true interpretation. If there is a difference in the specifications and drawings, the specifications will govern. Do not be belligerent with the contractor, but abide by your interpretation unless you are directed to do differently by the engineer.

20-8. **Approving Materials.** After the contract is under way, the inspector is responsible for seeing that only material on the Material Approved Lists is used. The specifications will specify the type and grade of materials that are to be used. In many instances, this will reference a guide specification number or a Federal specification number and then require a submittal. The inspector will need to research the specifications to determine the exact materials that are to be used. The submittal may be a sample or material or a manufacturer's certificate. All submittals must be

approved by the contracting officer (or his technical representative). The approved submittals should be cataloged and filed for reference.

20-9. **Rejecting Defective Materials.** The authority for rejecting defective materials is the specifications. Whenever the materials do not meet the requirements that are set forth in the specifications, the materials may be rejected. The specifications will specify the types and grades of the materials that are to be used, and it will be the inspector's responsibility to see that all materials will meet the requirements of all the approved submittals on the contract. The specifications may also specify certain conditions that the materials must meet. You must remember, though, that the grade of material for one phase of the construction may differ from the requirement for the same material at another phase. The specifications and the approved submittals are the inspector's control documents. It is the responsibility of the inspector to reject faulty material. If it is noted that material is being installed which is not included on the Material Approved Lists, you will inform the contractor and the engineering section. The base civil engineer will make recommendations to the contracting officer. The contracting officer will be the final authority in the rejection of material. Almost without exception, the contracting officer will accept recommendations from the inspector and the engineering office.

20-10. **Inspecting Workmanship.** The specifications will state that only skilled craftsmen will be used in all phases of the construction. Check the specifications for the cleaning and preparing of the surfaces. They may specify the methods of application for many of the different materials that are to be used. They may state that the contractor may use the manufacturer's recommendations. Work under a contract will be performed in a skillful and workmanlike manner. The contracting officer may require, in writing, the contractor to remove from the work any employee that the contracting officer deems incompetent, careless, or otherwise objectionable. The inspector is responsible for bringing to the attention of the contractor any unsafe condition or any unsafe practices of the workmen during their daily tasks. Good housekeeping and safe practices are a part of good workmanship. Proper equipment and good quality materials, in the hands of qualified craftsmen, will produce quality construction if properly supervised.

20-11. **Daily Diary.** The daily diary is the most important record maintained by the inspector. During the contractual period, the diary is referred to many times for information by the post engineer and the contracting officer. You, as an inspector, must record any information which may be of any possible assistance to the Contracting Officer in making decisions at a subsequent date. Examples of information are as follows:

Weather conditions. Weather conditions are very important when pouring concrete, painting, or asphalt laying. This data can be received from the post weather office or the nearest civil weather bureau. The data should be recorded as follows:

Temperature:	The high and low temperatures recorded during this 24-hour period.
Wind:	The velocity and directions of the wind.
Phenomena:	General overall weather conditions such as cloudy, clear, rain or overcast, etc.
Precipitation:	The amount of moisture received during the 24-hour period.

Contract number. This is the number assigned to the contract by the base procurement office.

Contractor. This is the primary contractor and the name of the superintendent. An example is: York's Plumbing Company, Mr. M. Hawley, Superintendent.

Contractor's employees on the job. List the number of employees by trade who are present on the job. Example: 4 painters, 10 electricians, etc.

Description of work. This will include a narrative of the work being accomplished. Building numbers should be included.

Progress. Include an estimate of the percent of the total job completed, a percentage of various portions of work completed and a statement as to whether or not the progress schedule is being met. Materials on site should be included in the progress estimate.

Supplies or materials. Include all Government-furnished equipment, material or supplies delivered to the contractor. List all material delivered to the job site by the contractor and all salvageable material turned in by the contractor. Backup documents should be filed in the contract jacket file which is maintained in the inspection section. These are only a few of the items to be included in the daily diary. There is no limit to the amount of information you may enter in this report. A good policy to follow is: if in doubt about anything, record it in the diary. Remember to always make complete entries.

EXAMINATION

ARMY CORRESPONDENCE COURSE • ENGINEER SUBCOURSE 563

PAINTING II

CREDIT HOURS ----------2

TEXT ASSIGNMENT ----------Review previous assignments.

EXERCISES

Requirement. Solve the following multiple-choice exercises.

1. Paint on softwoods will remain sound longest when it is applied on

a. edge-grain surfaces on the bark side

b. pith side of flat-grain boards

c. the summerwood

d. lightweight boards with narrow growth rings

2. Which of the following woods will best retain paint and resist weathering?

a. redwood
c. spruce

b. hemlock
d. Norway pine

3. Disintegration of a wood surface reveals boards that show distress of wood weathering. What is this stage of disintegration called?

a. chalking
c. wrinkling

b. checking
d. crawling

4. The application of a dissimilar paint over an old coating causes

a. tackiness
c. wrinkling

b. alligatoring
d. crawling

5. How do you prevent paint from running into the metal ferrule and down the handle of the brush?

a. dip brush into the paint only ½ inch

b. keep the bristles pointed downward

c. check the paint for proper mixing

d. tap tip of bristles against inside of container

6. You plan to spray enamel on screen cloth. Which of the following would you use to thin the enamel?

a. mineral spirits

b. flat finish paint

c. transparent varnish

d. hot linseed oil

7. When painting shingles for surface durability you would

a. overbrush primer with thinner

b. mop the surface with hot linseed oil

c. apply two coats of wood stain

d. leave as little binder as possible

8. Which of the following is a disadvantage in applying opaque paints with a roller coater to walls and ceilings?

a. will usually require two coats for consistent color coverage

b. self-leveling enamels cannot be applied with a roller

c. roller produces unwanted stipple finish

d. gloss paints dry flat when applied with roller

9. What is the least number of hours that you allow for drying between coats of varnish?

a. 10 c. 24

b. 15 d. 30

10. You must repair a gypsum plaster surface, to which you will apply three coats of the patching plaster. Which of the following lists the correct sequence of application?

a. brown, scratch, finish

b. brown, finish, scratch

c. scratch, finish, brown

d. scratch, brown, finish

11. You have applied a first coat of acrylic paint to a masonry surface. How many hours would you wait before applying a second coat?

a. 1 c. 8

b. 4 d. 12

12. You must repair a deep crack in a brick mortar joint where a leak must be stopped. You should chip out the old mortar to a depth of how many inches?

a. 2 c. 3½

b. 3 d. 4

13. You are using portland cement plaster to make a repair. You should allow the first coat to

a. cure by keeping it moist for at least 72 hours

b. dry thoroughly for not more than 24 hours

c. dry thoroughly for 5 days

d. cure by keeping it moist for a maximum of 8 hours

14. Which of the following would you use to remove old calcimine paint from a plaster wall?

a. water-base paint and varnish remover

b. warm water and detergent

c. turpentine

d. latex paint and varnish

15. A crack in plaster is large and well defined. It extends across the surface and goes entirely through the plaster. What do you call this kind of crack?

a. foundation c. shrinkage

b. structural d. map

16. On your post there is an overhead tank which is not obstructive. How would you paint this tank?

a. with coal-tar enamel overall

b. with yellow and black in checkerboard pattern

c. with aluminum or white paint

d. in alternate bands of green and black

17. You must fill small dents and cracks in a metal surface, and sand and prime them within an hour. Which of the following fillers would allow you to finish the job within the time set?

a. body filler
b. engraving filler
c. plastic paste filler
d. spackling compound

18. You must repair the protective coating on a wrapped underground pipe. You would

a. make double application of heated coal-tar enamel
b. wrap the pipe in four layers of felt
c. use red lead primer as finish coat
d. be sure that no holidays are left in wrappings

19. What is the approximate blasting pressure used for cleaning structural steel?

a. 40 to 60 psi
b. 80 to 100 psi
c. 100 to 130 psi
d. 150 to 180 psi

20. How many inches away from the surface would you hold the nozzle when you are abrasive-cleaning metal?

a. 2 to 6
b. 6 to 12
c. 12 to 18
d. 14 to 20

21. Which of the following would you use to remove oil, grease, or dirt from large metal surfaces?

a. sandblaster
b. impact tool
c. steam cleaner
d. chemical solution

22. You are using asphalt primer to repair felt and bituminous covered surfaces. For how many hours would you allow this primer to dry before you applied bituminous plaster cement?

a. 10
b. 15
c. 20
d. 24

23. Which of the following indicates corrosion on copper?

a. greenish-white color
b. white-blue powder
c. green patina
d. reddish scale

24. Coal-tar enamel protects underground steel pipe for years. How many years?

a. 5 to 10
b. 5 to 15
c. 10 to 15
d. 50 or more

25. A micrometer equipped with a vernier scale can be read to within

a. 0.01 inch
b. 0.001 inch
c. 0.0001 inch
d. 0.00001 inch

26. One gallon of aluminum applied to a wood surface will cover how many square feet?

a. 500
b. 600
c. 650
d. 700

27. What is the maximum amount of thinner that you would use per gallon of paint?

a. ½ pint
b. 1 pint
c. 1 quart
d. 3 pints

28. You are about to measure dry-film thickness with a properly calibrated dry-film thickness gage. How many measurements do you recommend should be made on a single area?

a. 25
b. 50
c. 75
d. hundreds

29. The process whereby a paint changes from a wet-film layer to a protective dry-film layer is called

a. mechanics of coatings
b. nonmagnetic shim
c. pigment exchange
d. disintegration

30. You are the inspector on a project that is being done under contract. Which of the following would you use for rejecting defective materials?

a. specifications
b. daily diary
c. contract
d. building plan

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